1184

The Description and Use OF A JOYNT-RULE:

Fitted with Lines for the finding the Hour of the Day, and Azimuth of the Sun, to any particular Latitude; Or to apply the same generally to any latitude

Together with all the uses of *Gunters* quadrant applyed thereunto, as Sun-rising, Declination, Amplitude, true place, right Ascension, and the hour of the Night by the Moon, or fixed Stars;

A speedy and easie way of finding of Altitudes at one or two stations; Also the way of making any kinde of erect Sun-Dial to any Latitude or Declination, by the same Rule: With the Description and Use of several Lines for the mensuration of *Superficies*, and *Solids*, and of other Lines usually put on Carpenters Rules:

Also the use of Mr. *Whites* Rule for measuring of Board and Timber, round and square; With the manner of using the *Serpentine-line* of Numbers, Sines, Tangents, and Versed Sines.

Contriv'd & written by J. Brown, *Philom.*

London, Printed by *T. J.* for *J. Brown*, and *H. Sutton*, and sold at their houses in the *Minories*, & *Thredneedle-street*. 1661.


P·R·fe

TO THE READER.

Courteous Reader,

AMong the multitude of Books which are printed and publiſhed, in this ſcribling Age, ſome ſerious, ſome ſeditious; ſome diſcovering or favouring of Art, others of ignorance, poſſibly every one endeavoring to bring their Male: Among the reſt of the crowd, I, like the widow, throw in my mite. If it be (or ſeem to be) little, it is like the Giver, and therefore I preſume will of ſome be accepted, as little as it is; and as little

worth as it is, it is like enough to be challenged: but I ſhall endeavor to prevent prejudice, by the following Diſcourſe.

Having for ſome time been enquiring to find out a way, whereby Work-men might on their Rules (their conſtant Companions) have a way eaſily and exactly to finde the hour of the Day, and Suns Altitude and Azimuth, and the like; and have at ſeveral times for ſeveral men, at their requeſt, uſed one and the other contrivance, to finde the Hour: as that of the Cillender, Quadrant, or the like, as the Altitude by a Tangent on the inſide of a Square, or Joynt-Rule, and the line of Sines on the flat ſide; but ſtill one inconvenience or other of trouble in adding of complements,

ments, or difficulty of taking of Aititudes, or trouble to the memory, did accrue to the work; or else the Radius was small, and so much the more short of exactness: at last there came to my sight a Quadrant made by Mr. *Thomson*, and as I was informed, was first drawn or contrived to that form, by Mr. *Samuel Foster*, that ingenious Artist, and laborious Student, and Reader of the Mathematicks in *Gresham* Colledge: And considering of the ease and speed in the using thereof, I set my self to the contriving thereof to a more portable form, at last took some pains in delineating one, and another in several forms, and enquired after the uses thereof, and in effect have done, as Mr. *Gunter* with

Stofflers Aſtrolabe, and *Nepeirs Logarithms*, and as Mr. *Oughtred* with *Gunters Rule*, to a ſliding and circular form; and as my father *Thomas Brown* into a Serpentine form; or as Mr. *Windgate* in his *Rule of Proportion*, and as of late Mr. *Collins* with Mr. *Gunters Sector on a Quadrant*, ſo may this not unfitly be called, *The Quadrant on a Sector*. And in fine, the Invention will be valued for the learned Authors ſake, and never a whit the worſe for the new Contrivers ſake: For firſt, hereby it is made large in little room, and as well on wood as on braſs, which is an incommunicable property to broad Quadrants, though of never ſo good matter, as experienced Workmen know right well; and by

by a Tangent of 30 degrees laid together, is gotten all kinde of Angles or Altitudes under 90 degrees, and to be afforded for a low price, in compariſon of other Inſtruments, which will not perform the ſame operations any better.

Having made ſome Joynt-Rules in the manner following, and expoſing them to ſale, I have been many times ſolicited to write ſomewhat of the uſe, and now at laſt after near a years ſuſpence, have committed the following Diſcourſe to publique view, partly to ſave the labor of tedious tranſcribings, and alſo to make ſo uſeful, cheap, and exact an Inſtrument, (if it be truly made) to be more known or occupied.

In which buſineſs, I deſire to diſclaim all vain-glorious oſtentation, and therefore have nakedly and plainly aſſerted the manner how, and why it comes to be publiſhed to the world by me. It is a mechanical thing, and mechanically applied, and of mechanical men will be humanically accepted, I doubt not. Having begun to write, I could not break off ſo ſhort and abruptly, as at firſt I did intend to do; therefore have added this ſhort Diſcourſe of ordinary Dyalling, the exact Method of which I finde in no other Author that ever I met with, (and indeed I have not time to read many) yet I dare preſume, that for ſpeed, eaſe, convenience, and exactneſs, inferior to none, eſpecially the way

way of making far declining Dyals; As for other declining reclining Dyals, I referre you to other Authors, or to a Diſcourſe thereof by it ſelf: if I finde encouragement, and ability to perform the ſame, a Copy whereof I have had a long time by me, written by a very ingenious Artiſt) the demonſtration of which Dyals is moſt excellently and eaſily ſhewed by the Figure inſerted, *page* 77.

As for the other part for taking of Altitudes and Angles, it may alſo be very conveniently done, if the Rule be fitted to a three-leg ſtaff, with a ſmall Ball-ſocket to ſet it level, or upright, as other Surveighing-inſtruments be, as will be amply found, if a tryal be made thereof.

That

That of Ma er *White*'s Rule is a thing that hath given very good content to ſeveral Gentlemen in the Counties of *Eſſex*, *Suffolk*, and *Norfolk*, and indeed is a very neat and accurate way of operation, well becoming a Gentleman; for while a Workman ſhall take meaſure, his Rule keeps the count of length, or breadth, and having the length firſt given, the girt or ſquareneſs is no ſooner agreed on, but you have the content without Pen or Compaſſes.

As for the other lines, as Decimal-board, and Timber-meaſure, Inches, and Foot, in the way of Reduction, Girt-meaſure, Circles, Diameter, Circumference, Squares inſcribed and equal: The Uſe of them will

will be very grateful to many a learner. Lastly, this brief touch of the Serpentine-line I made bold to assert, to see if I could draw out a performance of that promise, that hath been so long unperformed by the promisers thereof.

These Collections, courteous Reader, I have printed at my friends and my own proper charges, and if they prove to be (as I do hope they will) of publique benefit, I shall enjoy my expectation, and be ready at all times to serve you further, as I may, in these or other Mathematical instruments, at my house at the *Sun-dyal* in the *Minories*, and remain to you much obliged,

February 8. 1669. *John Brown.*

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The right Ascension and Declination of 12 principal fixed Stars in the heavens; most of which are inserted on the Rule: or if room will allow, all of them.

Stars Names	R. Asc. H.	M.	Declina. Deg.	M.
Pleiades, or 7 *Stars*	03	24	23	20
Bulls-Eye	04	16	15	48
Orions Girdle	05	18	01	19s
Little Dog	07	20	06	08
Lyons Heart	09	50	13	40
Lyons Tayl	11	30	16	30
Arcturus	14	00	21	04
Vultures Heart	19	33	08	00
Dolphins Head	20	30	14	52
Pegasus Mouth	21	27	08	19
Fomah ant	22	39	31	17s
Pegasus lower wing	23	55	13	19

Moneths	1	6	3	8	5	7	4
	9		11		2	10	12
Days	1	2	3	4	5	6	7
	8	9	10	11	12	13	14
	15	16	17	18	19	20	21
	22	23	24	25	26	27	28
	29	30	31				
Week-days	S	M	T	W	T	F	Sat
Dom. Letter	d	c	b	a	g	f	e
Leap-years	68	80	64	76	60	72	84
Epacts	26	9	12	25	28	11	23

THE Deſcription and Uſe OF A JOYNT-RULE.

CHAP. I.

The Deſcription of the Lines on the Rule, as it is made onely for one Latitude, and for the finding the hour of the day onely.

FIrſt open the (Joynt of the) Rule, then upon the head-leg, being next to your right hand, you have a line beginning at the hole, which is the Center of the quadrantal lines, and divided from thence downward toward the head, into as many degrees as the Suns greateſt

altitude in that latitude will be, which with us at *London* is to 62 degrees; which line I call the *Scale of Altitudes*, divided to whole, halfs, and sometime quarters of degrees.

2. Secondly, On the other leg, and next to the inside is the line of hours, usually divided into hours, quarters, and every fifth minute, beginning at the head with 4, and so proceeding to 5,6, 7,8,9,10,11, and 12 at the end, and then back again with 1, 2,3,4,5,6,7,8, for the morning and afternoon hours.

3. Next to this is a Kalendar of Moneths and Days in two lines; the uppermost contains that half year the days lengthen in, and the lowermost the shortning days, as by the names of the moneths may appear; the name of every moneth standing in the moneth, and at the beginning of the moneth: and all but the two moneths that have the longest, and the shortest days, *viz. June* and *December*, are divided into single days, the tenth day having a figure 10, or a point or prick on the head of the stroke,

ſtroke, and the fifth onely a longer ſtroke without a prick, and the beginning of every moneth a long ſtroke, and every ſingle day all alike of one ſhortneſs, according to the uſual manner of diſtinguiſhing on lines.

4. And laſtly you have a line of degrees, for ſo they be moſt properly called, and they are the ſame with the equal limb on quadrants, and ſerve for the ſame uſe, *viz.* for taking of Altitudes, or Horizontal Angles, and are divided uſually to whole, and half degrees of the quadrant, and figured with 30, 40, 50, 60|0, 70|10, 80|20, and 90, juſt on the head, cutting the center or point, where the Scale of Altitudes and the Line of Hours meet; which point, for diſtinction ſake, I call *The rectifying point.* And the reckoning on this line, as to taking of Altitudes, is thus: At the number 60|0 is the beginning, then towards the head count 10, 20, 30, where the 90 is; then begin at the end again, & count as the figures ſhew you to 90 at the head, as before.

CHAP. II.

The Uſes of the Rule follow.

1. *To Rectifie or ſet the Rule to his true Angle.*

OPen the Rule to 60 degrees, which is done thus, (indifferently:) make the lines on the head, and the lines on the other leg, meet in a ſtreight line; then is the Scale of Altitudes and the line of Hours ſet to an Angle of 60 degrees, the rectifying point, being the center of that Angle; Or to do it more exactly, do thus: put one point of a pair of Compaſſes into the rectifying point, then open the other to 10, 20, 30, or 40, on the Scale of Altitudes, the Compaſſes ſo opened, and the point yet remaining in the rectifying point, turn the other to that margenal line in the line of hours, that cuts the rectifying point, and there ſtay it; then remove the point that was fixed

ed in the rectifying point, and open or ſhut the Rule, till the point of the Compaſſes will touch 10, 20, 30, or 40, being the point you ſet the Compaſſes too in the Scale of Altitudes, in the innermoſt line that cuts the center, and the rectifying point, then is it ſet exactly to 60 degrees, and fitted for obſervation.

2. *To finde the Suns Altitude at any time.*

Put a pin in the center hole, at the upper end of the Scale of Altitudes, and on the pin hang a thread and plummet; then if the Sun be low, that is to ſay, under 25 degrees high, as in the winter it will always be, then lift up the moveable leg, where the moneths and the degrees be, till the ſhadow of the end fall juſt on the meeting of that leg with the head, then the thread ſhall ſhew the Suns altitude, counting from 60 to 0 towards the head, either 10, 20, 25, or any degree between.

But if the Sun be above 25 or 30 de-

grees high, lift up the head leg till the ſhadow of that play as before, or make the ſhadow of the pin in the center hole play on the innermoſt line of the Scale of Altitudes where the pin ſtandeth, then the thread will fall on the degree, and part of a degree that his true altitude ſhall be.

But if the Sun be in a cloud, and can not be ſeen ſo as to give a ſhadow, then look up along by the head-leg, or moveable leg, juſt againſt the middle of the round body of the Sun, and the thread playing evenly by the degrees, ſhall ſhow the true altitude required. The like muſt you do for a Star, or any other object, whoſe altitude you would find.

3. *Having found the Suns altitude, and the day of the moneth, to finde the hour of the day.*

Whatſoever you finde the altitude to be, take the ſame off from the Line of Altitudes, from the center downwards with a pair of Compaſſes, then lay the thread (being put over the pin) on the day

day of the moneth, then put one foot of the Compasses in the line of hours, in that line that cuts the rectifying point, and carry it further off, or nigher, till the other foot of the Compass being turned about, will just touch the thred, at the neareſt distance, then the point of the Compasses on the line of hours, shall shew the true hour and minute of the day required.

Example on the 2. *of* July.

1. I observe the altitude in the morning, and I finde it to be 30 degrees high, then laying the thread on the day of the moneth, and taking 30 degrees from the Scale of Altitudes, and putting one point in the line of hours, till the other point turned about, will but just touch the th·ead, and I finde it to 23 minutes past 7, but if it had been in the afternoon, it would have been 37 minutes past 4.

2. Again, on the tenth of *Auguſt* in the Afternoon, at 20 degrees high, I take 20 degrees from the Scale of Al-

tudes, and laying the thread on the day of the moneth, *viz.* the tenth aforesaid, counting from the name at the beginning of *August*, toward *September*, and carrying the Compasses in the line of hours, till the other point doth but just touch the thread, and you shall finde it to be 54 minutes past 4 a clock.

3. Again, on the 11. of *December* at 15 degrees high, work as before, and you shall finde it to be just 12 a clock; but to work this, you must lay the Rule down on something, and extend the thread beyond the Rule, for the nighest distance will happen on the out-side of the Rule.

4. Again, on the 11 of *June* at noon I finde the altitude to be 62 degrees high, then laying the thread on the 10*th* or 11*th* of *June*, for then a day is unsensible, and working as before, you shal finde the point of the Compasses to stay at just 12 a clock, the time required for that altitude.

4. *To*

4. *To finde the Suns riſing any day in the year.*

Lay the thread on the day of the month, and in the line of hours it ſheweth the true hour and minute of the Suns riſing or ſetting; for the riſing, count the morning hours; and for the ſetting, count the evening hours.

5. *To finde if any place lye level, or not.*

Open the rule to his true angle of 60 degrees, then ſet the moveable leg upon the place you would make level, and if the thread play juſt on 60 degrees, it is a true level place, or elſe not.

6. *To try if any thing be upright or not.*

Hang a thread and plummet on the center, then aply the head leg of the rule to the wall or poſt, and if it be upright, the thread will play juſt on the innermoſt line of the ſcale of altitudes, or elſe not.

CHAP. III.

A further description of the Rule, to make it to shew the Suns Azimuth, Declination, True place, right Ascention, and the hour of day or night, in this, or any other Lattitude.

1. First in stead of the scale of Altitudes to 62 degrees, there is one put to 90 degrees in that place, and that of 62 is put by in some other place where it may serve as well

2. The line of hours hath a double margent, *viz*, one for hours, and the other for Azimuths, & then every 5*th* minute is more properly made 4, or else every 2 minutes, and in a large rule to every quarter of a degree of Azimuth, or to every single minute of time.

3. The degrees ought to be reckoned after 3 maner of wayes: first as before is expreſt; secondly from 60 toward the end, with 10, 20, 30, 40, 50, 60, &c. to be so accounted in finding the Azimuth for a particular latitude; and thirdly

and thirdly from the head or 90, toward the end, with 10, 20, 30, 40, 50, 60, 70, 80, &c. for the general finding of Hour and Azimuth in any latitude, and many other problems of the Sphere besides; to which may be added, where room will alow, a line of hours, beginning at 6 at the head, and 12 at the end, but reckoning 15 degrees for an hour, and 4 minutes for every degree, it may do as well without it.

4. To the Kalender of moneths and days, is added a line of the Suns true place in the Zodiack, or where room fails, the Characters of the twelve Signs put on that day of the moneth the Sun enters into it, and counting every day for a degree, may indifferently serve for the use it is chiefly intended for.

5. Under that is a line of the Suns right Ascension, to hours and quarters at least, or rather every fifth minute, numbred thus: 12 and 24 right under ♈ and ♎, or the tenth of *March*, and so forward to the tenth of *June*, or ♋, where stands 6, then backwards to 12 where-

where you began, then backwards ſtill to the eleventh of *December*, with 13, 14, 15, 16, 17, 18, to ♑, then from thence forward to 24 where you firſt began: but when you are ſtreightned for room, as on moſt ordinary Rules you will be, then it may very well ſuffice to have a point or ſtroke, ſhewing when the Sun ſhall gradually get an hour of right Aſcenſion, and from that for every day count four minutes of time, till it hath increaſed to an hour more, and this computation will ſerve very well; and in ſtead of ſaying 13, 14, 15 hours of right Aſcenſion, ſay 1, 2, 3, &c. which will perform the work as well, and reduce the time to more proper terms.

6. There is fitted two lines, one containing 24 houres, and the other 29 days, and about 13 hours, and they ſerve to finde the time of the Moons coming to the South, before or after the Sun, and by that, the time of high-water at *London-bridge*, or any other place, as is ordinary.

CHAP.

CHAP. IV.

The Uſes follow in order.

1. *To finde the Suns Declination.*

LAy the Thread on the day of the moneth, then in the line of degrees you have the declination. From *March* the tenth toward the head is the Declination Northward, the other way is Southward, as by the time of the year is diſcovered.

Example:

On the tenth of *April* it is 11^d 48^l toward the North; but on the tenth of *October* it is 10^d 30^l toward the South.

2. As the thread is ſo laid on the day of the moneth, in the line of the Suns place, it ſheweth that; and in the line of the Suns right Aſcenſion, his right Aſcenſion alſo, onely you muſt give it its due order of reckoning, as thus: it begins at ♈ *Aries*, and ſo proceeds to ♋, then back again to ♑ at the eleventh

of

of *December*, then forwards again to ♈ *Aries*, where you began.

3. *To finde the Suns right Ascension in hours and minutes.*

Lay the thread as before, on the day of the moneth, and in the line of right Ascension you have the hour and minute required, computing right according to the time of the year, that is, begin at the tenth of *March*, or ♈ *Aries*, and so reckon forwards and backwards as the moneths go.

Example.

On the tenth of *April* the Suns place is 1 degree in ♉ *Taurus*, and the Suns right Ascension 1 hour 55 minutes: on the tenth of *October* $27^{d}\frac{1}{4}$ in ♎ *Libra*, and his right Ascension is 13 hours and 42 minutes.

4. *To finde the Suns Amplitude at rising or setting.*

Take the Suns Declination out of the particular Scale of Altitudes, and lay it the same way as the Declination is, from

from 90 in the Azimuth Scale, and it ſhall ſhew the Amplitude from the eaſt or weſt, counting from 90. Example: *May* the tenth it is 33. 37.

CHAP. V.

Having the Suns Declination, or day of the moneth to finde the Azimuth at any Altitude required for that day.

Firſt finde the Suns Declination, by the firſt Propoſition of the fourth Chapter, then take that out of the particular Scale of Altitudes, or ſcale to 62 degrees; then whatſoever the Altitude ſhall happen to be, count the ſame on the degrees from 60 toward the end of the Rule, according to the ſecond maner of counting, in the third Propoſition of the third Chapter, and thereunto lay the thred, then the Compaſſes ſet to the Declination, carry one point along the line of hours on the ſame ſide of the thread the Declination is; that is to ſay, if the day of the moneth,

moneth, or Declination be on the right side the Æquinoctial, then carry the Compasses on the right side; but if the Declination be on the South side, that is, toward the end, (counting from the tenth of *March*, or *Aries* or *Libra*, then carry the Compasses along the line of hours and Azimuths on the left side of the thread, as all winter time it will be, and having set the Compasses to the least distance to the thread, it shall stay at the Suns true Azimuth from the South required, counting as the figures are numbred; or from East or West, counting from 90.

Example 1.

On the tenth of *July* I desire to finde the Suns Azimuth at any Altitude, first on that day I finde the Suns Declination to be 20. 45, which number count from the beginning of the particular Scale of Altitudes toward 62, and that distance take between your Compasses, then are they set for all that day; then supposing the Suns height to be ten degrees, lay the thread on 10, counted from

from 60 toward the left end, then carrying the Compaſſes on the right ſide of the thread, (becauſe it is ſummer or north declination) on the line of Azimuths, it ſhall ſhew 110. 40, the Azimuth from the ſouth required; but if you count from 90, it is but 20. 40. from the eaſt, or weſt point northward, according to the time of the day, either morning or evening.

Example 2.

Again, on the 14. of *November*, or the 6. of *January*, when the Sun hath the ſame declination ſouth-ward, and the ſame Altitude, to work this you muſt lay the Rule down on ſomething, then lay the thread on the Altitude, counted from 60 toward the end (as before) and carrying the Compaſſes on the ſouth-ſide of the Æquinoctial, along the Azimuth-line, till the other point do but juſt touch the thread, and it ſhall ſtay at 36.45, the Azimuth from ſouth required; if it be morning, it wants of coming to ſouth; if it be after-noon, it is paſt the ſouth.

Ex-

Example 3.

But if the Sun be in the Æquinoctial, and have no declination, then it is but laying the thread to the Altitude, and in the line of Azimuths the thread ſhall ſhew the true Azimuth required. As for inſtance: at 00 degrees of altitude, the Azimuth is 90, at 10 degrees it is 77. 15, at 20 degrees 62. 45, at 30 degrees high 43. 15, at 35 degrees high 28. 10, at 38 degrees 28′ high, it is juſt ſouth, as by practice may plainly appear. But if the Suns altitude be above 45, then the degrees will go beyond the end of the Rule: To ſupply this defect, do thus: Subſtract 45 out of the number you would have, and double the remainder, then lay the Rule down with ſome piece of the ſame thickneſs, in a ſtreight line with the moveable leg; then take the diſtance from the tangent of the remainder doubled (counted from 60 to the end of the Rule, in the line next the edge) to the Center, lay that diſtance in the ſame ſtreight line from the tangent doubled,

doubled, and that ſhall be the tangent of the Angle above 45, whereunto you muſt lay the thread for the finding the Azimuth, when the Sun is above 45 degrees high. *(This ſupply was vſefull before ye croſs ſtaffe was added (from this ye) but ſince not ſo ma- (terial)*

CHAP. VI.

To finde the hour of the Night by the Moon.

FIrſt by the help of an Almanack, get the true time of the New Moon, then compute her true place at that time, which is always the place of the Sun (very nigh) at the hour and minute of conjunction; then compute how many days old the Moon is, then by the line of Numbers ſay: If 29 dayes 13 hours, (or on the line 29. 540) require 360 degrees, or 12 ſigns, what ſhall any leſs number of days and part of a day require? The anſwer will be: The Moons true place at that age. Having found her true place, then take her altitude, and lay the thred on the Moons place

place found, and work as you did for the Sun, and note what hour you finde; then consider if it be New Moon, the hour you finde is thē true hour, likewise in the Full; but if it be before or after, you must substract by the Line of Numbers thus: If 29 days 540 parts require 24 hours, what shall any number of days and parts require? The answer is: What you must take away from the Moons hour found, to make the true hour of the Night which was required.

But for more plainness sake, I will reduce these Operations to so many Propositions, before I come to an Example.

PROP. 1.

To finde the Moons Age.

First, it is most readily and exactly done by an Ephemerides, such a one as you finde in Mr. *Lilly's* Almanack, or (as to her Age onely) in any book or Sheet-Almanack; but you may do it in-

indifferently by the Epact thus, (by the Rules of the 152 page in the Appendix to the *Carpenters Rule.*) Adde the Epact, the moneth, and the day of the moneth together, and the ſum, if under 30, is the Moons age; but if above, conſider if the moneth have 30 or 31 days, then ſubſtract 29 or 30 out, and the remainder is the Moons age in days.

Example.

Auguſt 2. 1660. Epact 28. Month 6. day 2. added makes 36. Now *Auguſt* or ſixt moneth, hath 31 days, therefore 30 being taken away, 6 days remains for the moons age required.

PROP. 2.

To finde the Moons place.

By the Ephemerides aforeſaid in Mr. *Lilly*'s Almanack, you have it ſet down every day in the year; but to finde it by the Rule, do thus: Count ſix days back from *Auguſt* 2. *viz.* to *July* 27. there lay the thread, and in the line of the Suns place, you have the Moons place

place required, being then near alike; then in regard the Moon goes faſter than the Sun, that is to ſay, in 29 days 13 hours, 12 ſigns, or 360 degrees; in 3 days 1 ſign, 6 degr. 34 min. 20 ſec. in one day 0 ſigns, 12 degr. 11 min. 27 ſec. in one hour, 30 min. 29 ſec. (or half a minute:) adde the ſigns, and degrees, and minutes the Moon hath gone in ſo many days and hours, if you know them together, and the Sun ſhall be the Moons true place, being added to what ſhe had on the day of her change; but far more readily, and as exactly by the line of Numbers (or Rule of Three) ſay, if 29. 540. require 360. what 6 *facit* 73 $\frac{1}{4}$, that is, 2 ſigns, 13 degrees, 15 minutes, to be added to 14 degrees in ♌, and it makes 27 $\frac{1}{4}$ in ♎, the Moons place for that day. Or thus, multiply the Moons age by 4, divide the product by 10, the quotient ſheweth the ſigns, and the remainder multiplied by 3, ſheweth the degrees which you muſt adde to the Suns place on the day required, and it ſhall be the Moons

true

true place required for that day of her Age.

Example.

July 27. 1660 the Sun and Moon is in *Leo* 14 degr. ☌. *August* 2. being 6 days, adde the Moons motion 2. 13^d $9'$. makes being counted, *Virgo* ♍, *Libra* ♎. 27 deg. $9'$ the place required; which on the Rule you may count without all this work or trouble: but for plainnes sake I am constrained so to do. Or thus.

PROP. 3.

To finde the Moons hour.

To do this, you must do the work of the second Chapter, and second and third Proposition; where note that the Moons place found, is to be used as the day of the moneth, or Suns declination.

Example.

The Moon being 27 degrees in *Libra*, and 20 degrees high, I finde the hour to be $31'$ past 9, if on the east-side; or $29'$ past 2, if on the west-side of the Meridian.

PROP.

PROP. 4.

To finde the true hour of the Night.

Having found the Moons hour, as before, consider the Moons age, then say by the Line of Numbers, or Rule of Three, if 29. 540 part require 24, what shall 6 days require *facit* 4 hours and 52 minutes? which taken from 9. 31. rest 4. 39. the true time required.

Example.

Moons hour —	9	31
Time to be subst.	4	52
True time remain	3	39.

the time required. This work is done more readily by the two lines fitted for that purpose; for look for 6 the Moons age in one, and you shall finde 4 hours 52 minutes, the time to be substracted in the other.

CHAP

CHAP. VII.

To finde the hour of the Night by the fixed Stars.

FOr the doing of this, I have made choice of twelve principal fixed Stars, all within the two Tropicks; many more might be added, but theſe will very well ſerve the turn: The names of them, and their right Aſcenſion in hours and minutes, is ſet on the Rule, and the ſtar is placed in his true Declination on, or among the moneths; and for to know the ſtars next to a Tutor, a Celeſtial Globe, or a Nocturnal, of all the chief ſtars from the Pole to the Equinoctial, and to be had at the *Sun-Dial* in the *Minories*, is the beſt; the uſes whereof do follow.

Firſt know the ſtar you obſerve, then obſerve his Altitude, and laying the thread on the ſtar by the ſecond Chapter, ſecond and third Propoſition, get

the ſtars hour, then out of the righ
Aſcenſion of the ſtar, take the righ
Aſcenſion of the Sun, (found by th
fifth Propoſition of the third Chapter
for that day, and note the difference
for this difference added to the ſta
hours found, ſhall ſhew the hour o
the night.

Example.

On the firſt of *November* I obſerv
the Altitude of the *Bulls-eye*, and fin
it to be 30. then by ſecond and thir
of the ſecond Chapter, I finde th
hour to be 7. 54 paſt the Meridian
the Suns right Aſcenſion that day
finde to be 15 hours 8 minutes, th
ſtars right aſcenſion is 4 hours 16 mi
nutes; which taken, the greateſt fro
the leaſt, by adding of 24 hours, re
13. 08. then 7. 54. the ſtars hou
added, makes 21. 02. from which ta
king 12 hours, reſt 9. 02. the hour o
the night required. For more plain
neſs, note the work of two or thre
Examples.

Stars

Stars right Aſcenſion being ſet on the Rule ——————— 4—16
Suns right Aſc. *Nov.* 1. ——15—08

Subſtraction being made, by adding 24, remain ——————13—08
To which you muſt adde the ſtars hour found ——————————7—54

Then the remainder, taking away 12 hours, is ——————————9—02
the true hour.

Again May 15 *by* Arcturus, at 50 0 *high weſtwards.*

The right Aſc. of *Arcturus*, is 14h—0′
Suns right Aſc. *May* 15. is —4—10

The right Aſc. of the Sun taken from the R. Aſc. of the ſtar, reſt 9—50
The ſtars hour at 50 degr. high, found to be ——————————02—13

Which being added to the difference before, makes ——————11—03
or ~~11—03~~. *ſ. hyme required.*

Again January 5. *by the* Great-dog *at* 15 *degrees high east.*

The right Asc. of *Great-dog*, is 06 --2
The right Asc. of the Sun, is 19--5

Substr. made, by adding 24 h. is 10-3
Stars hour at 15 degr. high, is 9--3
Ante M. or P. Septen. Which added to the difference found, and 12 substracted, remains 8. 11'. for the true Hour of the Night required to be found, and so of any other star set down in the Rule, as by the trial and practice, will prove easie and ready to the ingenuous practitioner.

But by the line of 24, or twice 12 hours, and the help of a pair of Compasses, you may perform it without writing it down, thus: Take the right Ascension of the Sun, out of that line of hours between your Compasses (being always counted under 12) and set the same from the right Ascension of the star, toward a lesser number, to the beginning of the hours, and the

point ſhall ſtay at the remainder that is to be added to the ſtars hour found, then open the Compaſſes from thence to the beginning of the hours, and adde that to the ſtars hour found, and it ſhall reach to the hour of the night required.

Example.

Feb. 6. 1660. by *Arcturus* 20 degrees high: Take 10 hours 1 minute between your Compaſſes, and ſet it from 14 hours, or 2 hours beyond 12, and it ſhall ſtay at 3. 59: then take 3. 59, and adde it to 6. 24, the ſtars hour at 20 degrees high, and it ſhall be 10. 23, the hour of the night required.

CHAP. VIII.

To finde the Amplitude or Azimuth of the fixed Stars; alſo their riſing, ſetting, and ſouthing.

1. FIrſt for the Amplitude, take the ſtars declination from the parti-

cular Scale of Altitudes, and lay it from 90 in the Azimuth-line, and it ſhall ſhew his amplitude from Eaſt or Weſt toward South or North, according to the declination, and time of day, morning or evening. The ſame work is for the ſun.

Example:

The *Bulls-eye* hath 25. 54 degrees of amplitude, ſo hath the Sun at 15 degrees 48 minutes of declination.

2. To finde the Azimuth, work as you did for the Sun at the ſame declination the ſtar hath, by Chapter 5. and you ſhall have your deſire.

Example.

December 24. at 6 degrees high, by the *Bulls-eye* I finde the Azimuth to be 107. 53. from the ſouth.

3 To finde the ſtars riſing and ſetting, lay the thread on the ſtar among the moneths, and in the line of hours it ſhews the ſtars riſing and ſetting, as you counted for the Sun; but yet note this is not the time in common hours, but is thus found: Adde the com-

complement of the Suns Aſcenſion, and the ſtars right Aſcenſion, and the ſtars hour laſt found together, and the Sun, if leſs than 12; or the remain 12 being ſubſtracted, ſhall be the time of his riſing in common hours; but for his ſetting, adde the ſtars ſetting laſt found to the other numbers, and the ſum or difference ſhall be the ſetting.

Example.

For the *Bulls-eye* on the 23 of *December*, it riſeth at 2 in the afternoon, and ſets at 4. 46 in the morning.

4. To finde the time of the ſouthing of any ſtar on the Rule, or any other whoſe right aſcenſion and declination is known, Subſtract the Suns right aſcenſion from the ſtars, increaſed by 24, when you cannot do without, and the remainder, if leſs than 12, is the time required, in the afternoon or night before 12; but if there remain more than 12, ſubſtract 12, and the reſidue is the time from mid-night to mid-day following.

Example.

Lyons-heart on the tenth of *March*, the Suns Aſcenſion is 0 2′.
Lyons-heart whole right aſc. is 9 50′
Time of ſouthing is 9 48′ at night.

5. *To finde how long any Star will be above the Horizon.*

Lay the thread to the ſtar, and in the hour-line it ſheweth the aſcenſional difference, counting from 90; then note if the ſtar have North declination, adde that to 6 hours, and the ſum is half the time; if ſouth, ſubſtract it from 6, and the reſidue is half the time; and the complement of each to 24 being doubled, is the whole Nocturnal Arch under the Horizon.

Example.

For the *Bulls-eye*, his Aſcenſional difference will be found to be one hour, 23 minutes, which added to 6 hours and doubled, makes 14. 46, the Diurnal Ark of the Star, and the reſidue from 24 is 9. 14. for the No-

Nocturnal Ark, or the time of its being under the Horizon.

CHAP. IX.

To perform the fore-going work in any latitude, as rising, amplitude, ascensional difference, latitude, hour, and azimuth, wherein I shall give onely the rule, and leave out the examples for brevity sake.

1. FOr the rising, and setting, and ascensional difference, being all one, do thus: Take the Suns declination out of the general Scale of Altitudes, then set one foot of the Compasses in the colatitude on the same scale, and with the other lay the thred to the nigheſt distance; then the thred so laid, take the nigheſt distance from the latitude to the thread, with that distance set one foot in the Suns declination, counted from 90 toward the center, and the thread laid to the neareſt distance, shall in the degrees

ſhew the aſcenſional difference required, counting from 90 at the head toward the end of the Rule; and if you reduce thoſe degrees and minutes to time, you have the riſing and ſetting before and after 6, according to the declination and time of the year.

2. *To finde the Suns amplitude.*

Take the Suns declination, and ſetting one foot in the colatitude, with the other lay the thread to the neareſt diſtance, and on the degrees it ſheweth the Suns amplitude at riſing or ſetting, counting as before from 90 to the left end of the Rule.

3. *Having amplitude and declination, to finde the latitude.*

Take the declination from the general ſcale, and ſet one foot in the amplitude, the thread laid to the neareſt diſtance in the line of degrees, it ſheweth the complement of the latitude required, or the converſe.

4. *Ha-*

4. *Having latitude, Suns declination and altitude, to find the height at 6, and then at any other time of the day and year.*

Count the declination in the degrees from 90 toward the end, thereto lay the thread, the leaſt diſtance from which to the latitude in the general Scale, ſhall be the Suns height at 6 in the ſummer, or his depreſſion in the winter. The Compaſſes ſtanding at this diſtance, take meaſure on the general Scale of altitudes, from the beginning at the pin towards 90, keeping one point there, open the other to the Suns altitude, thus have you ſubſtracted the height at 6, out of the Suns altitude; but in winter you muſt adde the depreſſion at 6, which is all one at the ſame declination with his height at 6 in ſummer, and that is done thus: Put one point of the Compaſſes ſo ſet in the general Scale to the Suns Altitude, then turn the other outwards toward 90, there

there keep it, then open the Compaſſes to the beginning of the Scale, then have you added it to the Suns altitude; having this diſtance, ſet one foot in the colatitude on the general Scale, lay the thread to the neareſt diſtance; the thread ſo laid, take the neareſt diſtance from 90 to the thred, then ſet one foot in the declination, counted from 90, and on the degrees it ſheweth the hour from 6, reckoning from the head, or from 12, counting from the end of the Rule.

I ſhall make all more plain, by making three Propoſitions of it, thus:

Prop. 1. *To finde the hour in the Æquinoctial.*

Take the Altitude from the beginning of the general Scale of altitudes, and ſet one foot in the colatitude, the thread laid to the neareſt diſtance (with the other foot) in the degrees, ſhall ſhew the hour from 6, counting from 90, and allowing for every 15^{d} 1 hour, and 4 min: for every degree.

Prop. 2.

Prop. 2. *To finde it at juſt 6.*

Is before expreſt by the converſe of the firſt part of the fourth, which I ſhall again repeat.

Prop. 3. *To finde it at any time do thus.*

Count the Suns declination in the degrees, thereunto lay the thred, the leaſt diſtance, to which from latitude in the general Scale, ſhall be the Suns altitude at 6; which diſtance in ſummer you muſt ſubſtract from, but in winter you muſt add to the Suns preſent altitude; having that diſtance, ſet one foot in the colatitude, with the other lay the thread to the neereſt diſtance, take again the neereſt diſtance from 90 to the thread, then ſet one foot in the Suns diclination counted from 90, and lay the thread to the neereſt diſtance, and in the degrees it ſhall ſhew the hour required.

Example.

At 10 declination notth, and 30 high, latitude 51.32, the hour is found

to

to be 8. 25, counting 90 for 6, and so forward. Again at 20 degrees of declination South, and 10 degrees of altitude, I finde the hour in the same latitude to be 17 minutes past 9.

Having latitude, delination, and altitude, to finde the Suns Azimuth.

Take the sine of the declination, put one foot in the latitude, the thread laid to the neereſt diſtance: in the degrees, it ſheweth the Suns height at due East or West, which you muſt in ſummer ſubſtract from the Suns altitude, as before on the general Scale of Altitudes, with which diſtance put one foot in the colatitude, and lay the thread to the neereſt diſtance, then take the neereſt diſtance from the ſine of the latitude, fit that again in the coaltitude, and the thread laid to the neereſt diſtance, in the degrees ſhall ſhew the Suns Azimuth required.

6. *But in winter you muſt do thus:*
By the ſecond Propoſition of the ninth

ninth Chapter, finde the Suns Amplitude for that day, then take the altitude from the general Scale of altitudes, and putting one point in colatitude, lay the thread to the neereſt diſtance, then the neereſt diſtance from the latitude muſt be added to the Suns Amplitude; this diſtance ſo added muſt be ſet from the coaltitude, and the thread laid to the nigheſt diſtance, and in the line of degrees, it gives the Azimuth from ſouth, counting from the end of the rule, or from the Eaſt or Weſt, counting from the head or 90 degrees.

Example.

At 15 degrees of declination and 10 altitude, latitude 51. 32. the Azimuth is 49. 20. from the South, or 40 degrees and 40′ from Eaſt or Weſt.

CHAP.

CHAP. X.

To finde all the neceſſary queſita for any erect declining Sun-dial both, particularly and general, by the lines on the Dial ſide, alſo by numbers, ſines, and tangents artificial, being Logarithms on a Rule.

1. *Firſt a particular for the Subſtile.*

COunt the plains declination on the Azimuth ſcale, from 90 toward the end, and thereunto lay the thread, in the line of degrees it ſhews the diſtance of the ſubſtile from 12.

Example.

At 10 *degrees declination, I find* 7.51. *for the ſubſtile.*

2. *For the height of the ſtile above the ſubſtile.*

Take the Plaines Declination from 90 in the Azimuth line, but counted from the South end, between your compaſſes: and meaſure it in the particular ſcale of altitudes, and it

it ſhall give the height of the ſtile required.

Example.

At 30 declination is 32. 35.

3. *For the inclination of Meridians:*

Count the ſubſtile on the particuler ſcale of Altitudes, and take that diſtance between your compaſſes, meaſure this diſtance on the Azimuth line from 90 toward the end, and counting that way it ſheweth the inclination of Meridians required.

Example.

At 15 the ſubſtile, the inclination of Meridians will be found to be 24.36.

4. *To finde the Angle of 6 from 12.*

Take the plaines declination from the particular ſcale of altitudes, and lay it from 90 on the Azimuth ſcale, and to the Compaſſes point lay the thread: then on the line of degrees you have the complement of 6 from 12, counting from 60 toward the end.

Note

Note this Rule (as this line is drawn) doth not give this Angle exactly, neither will it be worth the while to delineate another line for this purpose. But if it be required it may be done, but I rather prefer this help, the greatest error is about the space of 45 minutes of the first degree in the particular scale of altitudes; so that if you conceive those 45 minutes to be divided as the particular scale of altitudes is, like a natural line, and if your declination be 30, then take half the space of the 45 minutes less, and that shall be the true distance to lay on the Azimuth line from 90 whereunto to lay the thread.

Example.

A plaine declining 30 degrees, the angle will be found to be 32. 21. whose complement 57. 49. is the angle required.

5. *To perform the same generally by the general scale of altitudes; and first for the stile.*

Lay

Lay the thred to the complement of the latitude, counted in the degrees from the head toward the end, then the nigheſt diſtance from the complement of the plaines declination to the thread, taken and meaſured on the general ſcale, from the center, ſhall be the ſtiles height required.

6. To finde the inclination of Meridians. Difference of plaine & Longitude

Take the plaines declination, from the general ſcale, and fit it in the complement of the ſtiles elevation, and lay the thread to the neereſt diſtance, and on the degrees it ſheweth the inclination of Meridians required.

7. For the ſubſtile. Line of Declination

Count in the inclination of Meridians on the degrees from 90, and thereto lay the thread, then take the leaſt diſtance from the latitudes complement to the thread, ſet one foot of that diſtance in 90, and lay the thread to the neereſt diſtance, and in the de-

degrees it ſhall ſhew the ſubſtile from 12 required.

8. *For the angle of 6 from 12.*

Take the ſide of the ſquare, or the meaſure of the parallel from 12, and fit it in the coſine of the latitude, and lay the thread to the nigheſt diſtance, then take out the neareſt diſtance from the ſine of the latitude to the thread, then fit that over in the ſine of 90, and to the neareſt diſtance lay the thread, then take the neareſt diſtance from the ſine of the plains declination to the thread, and it ſhall reach on the parallel line, or ſide of the ſquare, from the Horizon to 6 a clock line required.

Four Canons to work the ſame by the artificial ſines & tangents.

The plains difference of longitude or Inclination of Meridians.

As the Sine of the latitude,
To the Sine of 90:
So the Tangent of the Declination, of the wall

To

To the Tangent of inclination of the Meridians.

Stiles Elevation.

As the Sine of 90,
To the Cosine of the Declination:
So the Cosine of the latitude,
To the Sine of the Stiles elevation.

Substile from 12.

As the Sine of 90,
To the Sine of the Declination:
So the Cotangent of Latitude,
To Tangent of the Substile from 12:

For 6 and 12.

As the Cotangent of the Latitude, 1
To the Sine of 90: 3
So is the sine of Declination, 2
To the Cotangent of 6 from 12. 4

For the hours.

As the Sine of 90,
To the Sine of the Stiles height:
So the Tangent of the hour from the proper Meridian,

To

To the Tangent of the hour from the Substile.

The way to work these Canons on the Sines and Tangents, is generally thus: As first, for the inclination of Meridians, set one point in the Sine of the latitude, open the other to the Sine of 90, that extent applied the same way, from the Tangent of the Plains declination, will reach to the Tangent of the inclination of Meridians required.

CHAP. XI.

To draw a Horizontal Dyal to any latitude.

First draw a streight line for 12, as the line A B, then make a point in that line for a Center, as at C, then through the Center C, raise a perpendicular to A B, for the two six a clock hour-lines, as the line D E; then draw two occult lines parallel to A B, as

as large as the Plain will give leave, as D E, and E G then fit C D in the Sine of the Latitude, in the general Scale, and lay the thread to the nigheſt diſtance, then take the neareſt diſtance from 90 to the thread, and ſet it from D and E in the two occult lines, to F and G, and draw the line F and G parallel to the two ſixes, (or make uſe of the Sines on the other ſide, thus: Fit A D, or C D in the Sine of the latitude, and take out the Sine of 90, and lay it as before from D and E,) then fit D F, or E G in the Tangent of 45 degrees, on the other ſide of the Rule, and lay off 15, 30, and 45, for every whole hour, or every 3 degrees and 45 minutes for every quarter, from D and E, toward F and G, for 7, 8 9, and for 3, 4, and 5 a clock hour points. Laſtly, ſet C D, or B E in the Tangent of 45, and lay the ſame points of 15, 30, 45, both wayes, from B or 12, for 10, 11, and 1, 2, and to all thoſe points draw lines for the true hour-

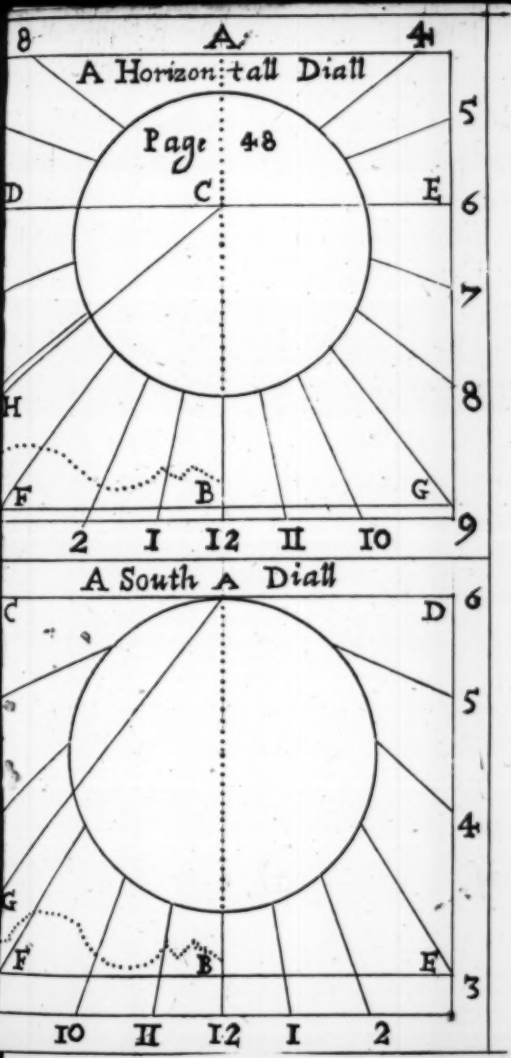
lines

lines required, for laying down the Stiles height; if you take the latitudes complement, out of the Tangent-line as the Sector ſtood, to prick the noon hours, and ſet it on the line D F, or E G, from D or E downwards from D to H, it will ſhew you where to draw C H for the Stile, then to thoſe lines ſet figures, and plant the Dial Horizontal, and the Stile perpendicular, and right north and ſouth, and it ſhall ſhew when the ſun ſhineth, the true hour of the day. Note well the figure following.

CHAP. XII.

To draw a Vertical, Direct, South, or North Dyal.

FIrſt draw a perpendicular line for 12 a clock, then in that line at the upper end, in the ſouth plain: and at the lower end in a north plain, appoint a place for the center, through which point croſs it at right angles, for


A
A Horizontall Diall
Page 48
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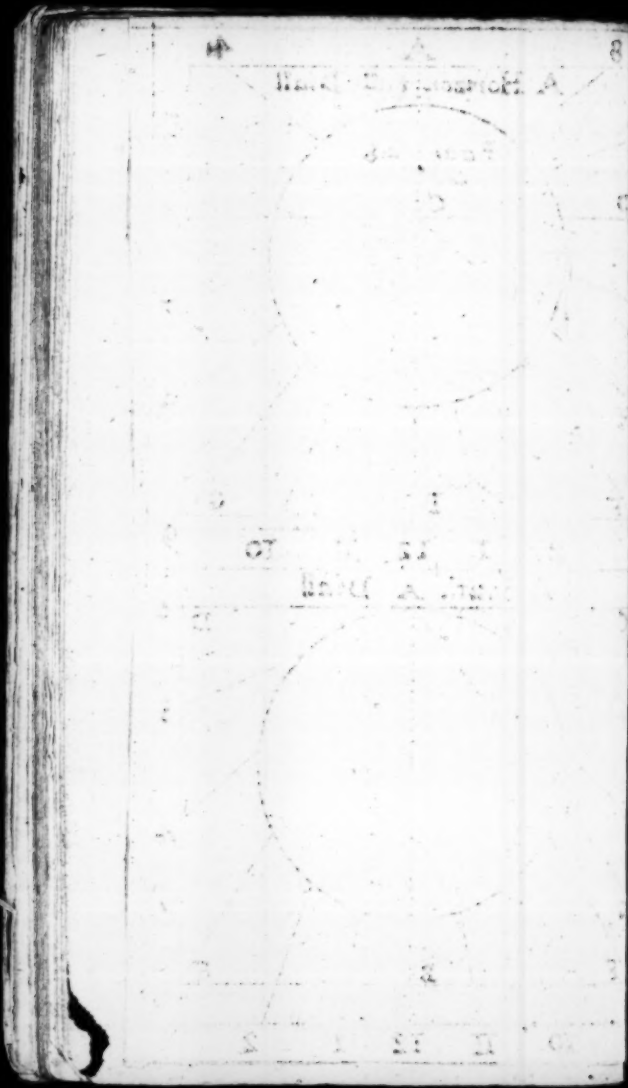


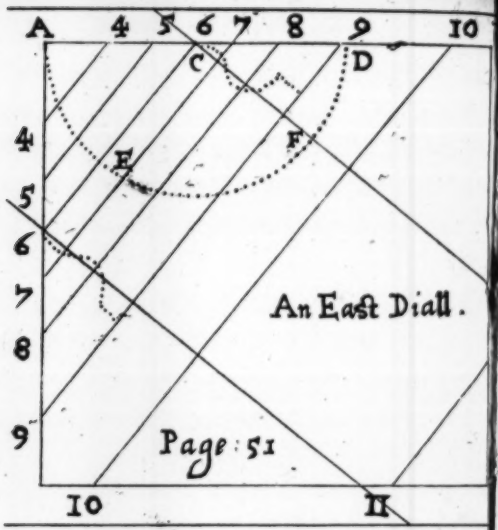
for 6 and 6, as you did in the Horizontal Plain, as the lines A B, and C D, on each ſide 12 make two parallels, as in the Horizontal, then take A D the parallel, and fit it in the ſine of the latitudes complement, and take out the ſine of 90 and 90, and lay it in the parallels from D and C, to E and F, and draw the line E F, then make D E, and B E tangents of 45, and lay down the hours as you did in the horizontal, and you ſhall have points whereby to draw the hour lines.

For the north you muſt turn the hours both ways for 4, 5, 8 and 7 in the morning and 4, 5, 7 and 8, at night the height of the ſtile muſt be the tangent of the complement of the of the latitude when the ſector is ſet to lay off the hours from D, as here it is laid down from C to G, and draw the line A G for the ſtile. For illuſtration ſake note the figure.

CHAP. XII.

To draw an erect East or West Dial.

First by the fifth Proposition of the second Chapter draw a horizontal line, as the line A B at the upper part of the plaine. Then at one third part of the line A B, from A the right end if it be an East plaine, or from B the left end, if it be a West Plain, appoint the center C, from which point C draw the Semicircle A E D, and fit that radius in the sine of 30 degrees, (which in the Chords is 60 degrees) then take out the sine of half the latitude, and lay it from A to E, and draw the line C E for six in the morning on the East, (or the contrary way for the West.) Then lay the sine of half the complement of the latitude, from D to F, and draw the line C F, for the contingent or equinoctial line, to which line you must draw another line parallel, as far asunder


A
4
5
6
7
8
9
10
C
D
E
F
An East Diall.
Page 51
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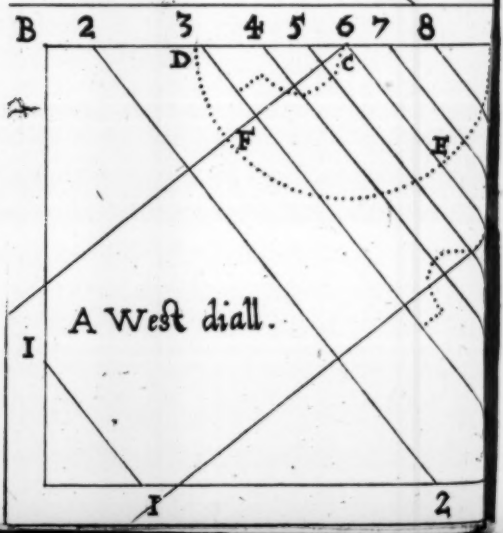
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aſſunder as the plaine will give leave, then take the neereſt diſtance from A to the ſix a clock line, or more or leſs as you beſt fancy, and fit it in the tangent of 45 degrees, and prick down all the houres and quarters, on both the equinoctial lines, both ways from ſix, and they ſhall be points, whereby to draw the hoor lines by, but for the two houres of 10 and 11 there is a leſſer tangent beginning at 45, and proceeding to 75, which uſe thus: fit the ſpace from ſix to three, in the little tangent of 45, and then and then lay of 60 in the little tangents from 6. to 10, and the tangent of 75 from 6 to 11, and the reſpective quarters alſo if you pleaſe, ſo have you all the houres in the Eaſt, or weſt Diall, the diſtance from ſix to nine or from ſix to three, in the Weſt, is the height of the ſtile, in the Eaſt and Weſt Diall, and muſt ſtand in the ſix a clock line, and parrallel to the plaine.

CHAP. XIII.

To finde the declination of any Plain.

FOr the finding of the declination of a Plain, the moſt uſual and eaſie way, is by a magnetical needle fitted according to Mr. *Failes* way, in the index of a Declinatory; or in a ſquare box with the 90 degrees of a quadrant on the two ſides, or by a needle fitted on the index of a quadrant, after all which ways, you may have them at the Sign of the *Sphere* and *Sun-Dial* in the *Minories*, made by *John Brown.*

But the work may be very readily and exactly performed by the rule, either by the Sun or needle in this manner following, of which two ways that by the Sun is always the beſt, and moſt exact and artificial, and the other not to be uſed (if I may adviſe) but when the other failes, by the Suns not ſhining, or as a proof or con-

confirmation of the other.

And first by the needle because the easiest.

For this purpose you must have a needle well touched with the Loadstone of about three or four inches long, and fitted into a box somewhat broader then one of the legs of the sector, with a lid to open and shut; and on the inside of the lid may be drawn a South erect Dial, and a wire to set the lid upright, and a thread to be the Gnomon or stile to that Dial: it will not be a miss also to extend the lines on the Horizontal part for the same thread is a stile for that also. Also on the bottom let there be a rabbit, or grove, made to fit the leg of the rule or sector; so as being pressed into it, it may not fall off from the rule, if your hand should shake, or you cease to hold it there. This being so fitted, the uses follow in their order.

Put your box and needle on that leg of the rule, that will be most fit

for your purpoſe, and alſo the north end of the needle toward the wall, if it be a ſouth wall; and the contrary, if a north, as the playing of the needle will direct you, better then the way how in a thouſand words, then open or cloſe the Rule, till the needle play right over the north and ſouth-line, in the bottom of the Box: then the complement of the Angle that the Sector ſtandeth at (which may always be under 90 degrees) is the declination of the Plain. But if it happen to ſtand at any Angle above 90, then the quantity thereof above 90, is the declination of the wall.

To finde the quantity of the Angle the Sector ſtands at may be done two ways: firſt by protraction, by laying down the Rule ſo ſet on a board, and draw two lines by the legs of the Sector, and finde the Angle by a line of Chords. Secondly, more ſpeedily and artificially, thus: By the lines of Sines being drawn to 2. 4, or 6 degrees aſunder. The Sector ſo ſet, take

the parallel ſine of 30 and 30, and meaſure it on the lateral ſines from the center, and it ſhall reach to the fine of half the Angle the line of ſines ſtands at, being more by 2, 4, or 6 degrees then the ſector ſtands at, becauſe it is drawn one, two, or three degrees from the inſide.

Or elſe take the latteral ſine of 30 from the center, and keeping one foot fixed in 30, turn the other till it croſs the line of ſines on that line next the inſide, and counting from 90, it ſhall touch at the Angle the line of ſines ſtands at, being two degrees more then the Sector ſtands at; the lines being drawn ſo, will be (as I conceive) moſt convenient.

Take an Example.

I come to a ſouth-eaſt-wall, and putting my box and needle on my Rule, with the croſs or north-end of the needle toward the wall, and the Rule being applyed flat to the wall, on the edge thereof, on the eveneſt place,

place thereof, and held level, ſo as the needle may play well with the head of the Rule toward your right hand, as you ſhall finde it to be in an eaſt-wall moſt convenient; then I open or cloſe the Rule, till the needle play right over the north and ſouth line in the bottom of the box; then having got the Angle, (take off the box, or if you put it on the other ſide that labor may be ſaved.) I take the parallel fine of 30, and meaſuring it from the center it reaches, ſuppoſe to the fine of 20, then is the line of fines at an Angle of 40 degrees, but the Sector at two degrees leſs, *viz.* 38 degrees, whoſe complement 52 is the declination; then to conſider which way, minde thus: Firſt it is ſouth, becauſe the ſun being in the ſouth, ſhines on the wall. Secondly conſider, the ſun being in the eaſt, it ſhines alſo on the wal, therefore it is eaſt plain: thus have you got the denomination which way, and alſo the quantity how much that ways.

Or

Or if you take the latteral ſine of 30 from the center, and turn the point of the Compaſſes from 30 towards 90, on the other leg you ſhall finde it to reach to the ſine of 50 degrees, whoſe complement, counting from 90, is 40, or rather 38, for the reaſon before-ſaid, or elſe adde 2 to 50, and you have the angle required, without complementing of it, being the true declination ſought for. Thus by the needle you may get the declination of any wall, which in cloudy weather may ſtand you in good ſtead, or to examine an obſervation by the Sun, as to the miſ-counting or miſtaking therein; but for exactneſs the Sun is alwayes the beſt, becauſe the needle, though never ſo good, may be drawn aſide by iron in the wall, and alſo by ſome kinde of bricks, therefore not to be too much truſted unto.

To finde a Declination by the Sun.

Firſt open the Rule to an Angle of 60 degrees, as you do to finde the

hour of the day, and put a pin in the hole, and hang the thread and plummet on the pin; also you must have another thread somewhat longer and grosser then that for the hour in a readiness for your use.

Then apply the head leg to the wall, if the sun be coming on the Plain, and hold the Rule horizontal or level, then hold up the long thread till the shadow falls right over the pin, or the center hole, at the same instant the shadow shall shew on the degrees, how much the sun wants of coming to be just against the Plain, which I call the Meridian or Pole of the Plain, which number you must write down thus, as suppose it fell on 40, write down 40--00 want: then as soon as may be take the Suns true altitude, and write that down also, with which you must finde the Suns Azimuth, then substract the greater out of the [illegible], and the remainder is the declination required. But for a general rule, take this: if the Sun do

want of coming to the Meridian of the place, and also want of coming to the Meridian of the Plain, then you must alway substract the lesser number out of the greater, whether it be forenoon or after-noon, so likewise when the Sun is past the Meridian, and past the Plain also. But if the signes be unlike, that is to say, one past the Plain, or Meridian, and the other want either of the Plain, or Meridian, then you must add them together, and the sum is the declination from the South. Which rule for better tenaciousness sake take in this homely rime.

Signs both alike substraction doth require,
But unlike signs addition doth desire.

The further illustration by two or three Examples.

Suppose on the first of *May*, in the forenoon, I come and apply the Rule, being opened to his Angle of 60 degrees to the wall, (*viz.* the head leg

or the leg where the center is) and holding up my thickeſt thread and plummet, ſo as the ſhadow of it croſſeth the center, and at the ſame inſtant alſo on 60 degrees, then I ſay the ſun wants 60 deg. of coming to the Meridian of the Plain; at the ſame inſtant, or as ſoon as poſſible I can, I take the ſuns altitude, as before is ſhewed, and ſet that down, which ſuppoſe it to be 20 degrees, then by the rules before, get the Suns azimuth for that day, and altitude; which in our example will be found to be 94 degrees from the (ſouth or) Meridian, then in regard the ſigns are both alike, *i. e.* want, if you ſubſtract one out of the other, there remains 34 the declination required; but for the right denomination which way, either north or ſouth, toward either eaſt or weſt, obſerve this plain rule: Firſt, if the Sun come to the Meridian or Pole of the Plain, before it come to the Meridian or Pole of the place, then it is always an Eaſt-plain; but if

the contrary, it is a Weſt-plain, that is to ſay, if the Sun come to the Meridian or Pole of the place, before it comes to the Meridian or Pole of the Plain, then it is a Weſt-plain. Alſo if the ſum or remainder, after addition or ſubſtraction, be under 90, it is a South-plain; but if it be above 90, it is a North-plain. Alſo note, that when the ſum or remainder is above 90, then the complement to 180, is always the declination from the north toward either eaſt or weſt; So that according to theſe rules in our example it is 34 degrees South-eaſt.

Again in the morning, *June* 13. I apply my rule to the wall, and I finde the Sun is paſt the Pole or Meridian of the Plain 10 degrees, and the altitude at the ſame time 15 degrees, the Azimuth at that altitude, and day in this latitude, will be found to be 109 degrees want of ſouth or pole of the place; therefore unlike ſigns, and to be added, and they make up 119 degrees, whoſe complement to 180

is

is 61; for 61 and 119 added, make up 180, therefore this Plain declineth 61 degrees from the north toward the east.

Again the same day in the afternoon, I finde the Azimuth past the south or meridian of the place 30 degrees, and at the same time the Sun wants in coming to the meridian or pole of the Plain 10 degrees, here by addition I finde the declination to be 40 degrees south-west.

Note what I have said in these three examples, is general at all times; but if it be a fair day, and time and opportunity serve, to come either just at 12 a clock, when the Sun is the meridian or pole of the place; or just when the Sun is in the meridian or pole of the Plain, then your work is onely thus:

Firſt if you come to obſerve at 12, then applying your rule to the wall, and holding up the thread and plummet, how much ſo ever the Sun wants or is paſt the pole of the Plain, that is

is the declination, if it be paſt it is eaſt-wards; if it wants, it is ſouth-weſt-wards; if neither, a juſt South Plain, and then the poles, or Meridians of place and Plain, are the ſame.

But ſecondly, if you come when the Sun is juſt in the pole of the Plain, then whatſoever you finde the Suns Azimuth to be, that is the declination; if it wants of ſouth, it declineth Eaſt-wards; if it be paſt, it declineth Weſt-wards.

Thus I have copiouſly, (and yet very briefly) ſhewed you the moſt artificial way of getting the declination of any wall, howſoever ſituated.

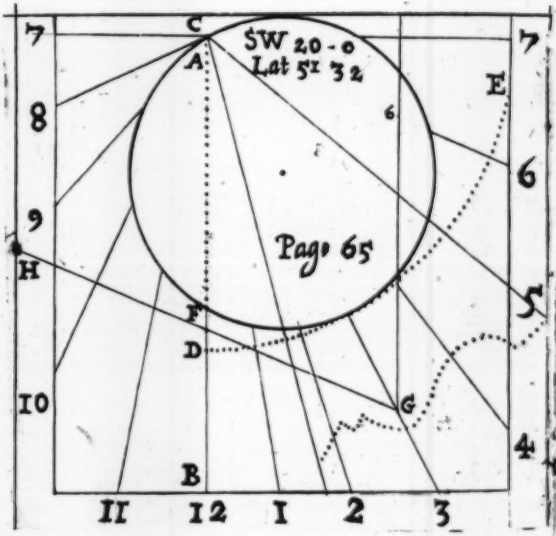
☞ Note if the Sun be above 15 degrees wanting of the Meridian of the Plain, your rule will prove defective in taking the Plains Meridian when the center leg is next the wall, then you muſt turn the other leg to the wall, and then you finde a ſupply for all angles to 45 degrees paſt the Plain. But for the ſupply of the reſt which is 45 degrees, do thus: open the rule till the great

great line of tangents & the outside of the leg make a right angle, for which on the head you may make a mark for the ready setting, then making the inside of the leg at the end of 45, as a center, the tangents on the other leg supply very largely the defect of the other sides. Or if you set on the box and needle on the rule, and open or shut the rule till the shadow of the thread shew just 12, then the Angle the Sector stands at, is the complement of what the sum wants, or is past the meridian or pole of the Plain.

CHAP. XIV.

To draw a vertical declining Plain to any declination.

First draw a perpendicular-line for 12, as A B then design a point in that line for the center, as C, at the upper end, if it be a South Plain; or contrary, if it be a North Plain, then on that center describe an Arch of a Circle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Circle on that ſide of 12, which is contrary to the Plains declination, as DE, and in that Arch lay off from 12 the ſubſtile, and on that the ſtiles height, and the hour of 6, being found by the tenth chapter, and draw thoſe lines from C the center, then draw two parallels to 12, as in the direct ſouth: then fit the diſtance of the parallels in the ſecant of the declination, and take the ſecant of the latitude, and ſet it from the center C on the line of 12, to F, and on the parallel from 6 to G, and draw a line by thoſe two points F and G, to cut the other parallel in H: then have you found 6, 3, and 9, then fit 6 G in the tangent of 45, and prick off 15, 30, and the reſpective quarters both ways from 6, for the morning, and afternoon hours, then fit F G in 45, and lay off the ſame points from F both ways for 10, 11, 1, and 2, and the quarters alſo, if you pleaſe, and thoſe ſhall be points to draw the hour-lines by. The ſtile muſt be ſet perpendicular

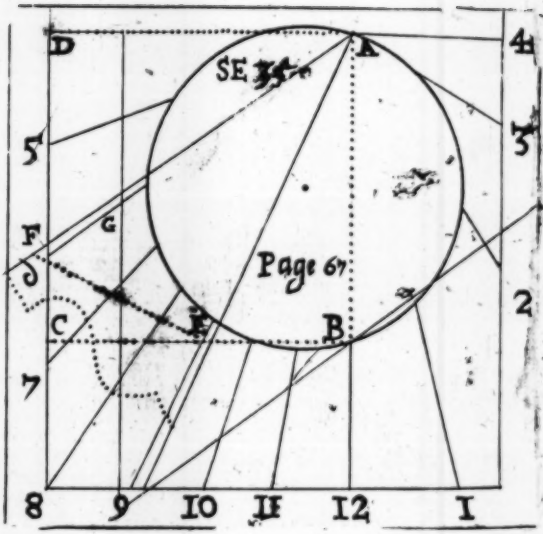
cular over the ſubſtile, to the Angle found by the rules in the tenth chapter, and then the Dial ſhall ſhew the true hour of the day, being drawn fit to his proper declination.

Another way to perform this Geometrically for all erect Dyals with centers.

When you have drawn a line of 12, and appointed a center, make a Geometrical ſquare on that ſide 12, as the ſtile muſt ſtand on, as A B C D, the perpendicular ſide of which ſquare may alſo be the parallel as before.

Then firſt, fit the ſide of the ſquare in the ſine of the latitude, and take out the coſine of the latitude, and fit that in the ſine of 90; the Sector ſo ſtanding, take out the ſine of the declination, and lay it from B toward C, unto E, and draw A E for the ſubſtile, then upon the point E in the ſubſtile, raiſe a perpendicular, and take out the ſine complement of the Plains declination, and ſet it on that perpendicular from E to F, for the

height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height of the ſtile above the Plain.

Again, fit the ſide of the ſquare in the coſine of the latitude, and take out the parallel line of the latitude, and fit that over in the line of 90, then take out the parallel line of the declination, and lay it from D to G for the hour of 6, and draw the line A G for the 6 a clock hour line.

Then again, fit the ſide of the ſquare (or the diſtance of the parallel in the other way, when you want a ſecant, or your ſecant too little) in the line of 90, and take out the coſine of the declination, fit that in the coſine of the latitude, then take out the line of 90, and lay it from the center on the line of 12, and from 6 in the ſide of the ſquare, and by thoſe two points draw the contingent line, and then fit thoſe points or diſtances in the tangent of 45, and lay down the hours as in the former part of this chapter; but if you want the hours before 9 in weſt-decliners, or the hours after 3 in eaſt-decliners, and the 6 fall too high a-

bove

bove the horizontal line on that ſide, you may ſupply this defect thus:

Take the meaſure with your Compaſſes from 3 to 4 and 5, upwards in the weſt-decliners, or from 9 to 7 and 8 in eaſt-decliners, and lay it upwards from 9 or 3 on the deficient ſide, in the parallel as it ſhould have been from 6 downward in ſouth, or upward in north Plains, and you ſhall ſee all your defective points to be compleatly ſupplied, whereunto draw the hour-lines accordingly.

CHAP. XV.

To draw the Hour-lines on an upright declining Dial, declining above 60 degrees.

IN all erect Decliners, the way of finding the ſtile, ſubſtile 6 and 12, and inclination of Meridians, is the ſame; but when you come to protract, or lay down the hour-lines, you ſhall finde them come ſo cloſe together

ther, as they will be uſeleſs, unleſs the ſtile be augmented.

The uſual way for doing of which, is to draw the Dial on a large floor, and then cut off ſo much and at ſuch a diſtance, as beſt ſerveth your turn, but this being not always to be affected, for want of conveniency, and large inſtruments, it may very artificially be done by a natural tangent of 75 or 80 degrees, fitted on the legs of a ſector in this manner.

The example I ſhall make uſe of, let be a Plain declination 75 degrees, South, Weſt.

Firſt on the north edge of the Plain draw a perpendicular-line A B, repreſenting 12 a clock line; then on the center draw an occult Arch of a circle as large as you can, as B D, therein lay off an angle of 37. 30 for the ſubſtile, (though indeed this line will not prove the very ſubſtile, yet it is a parallel to it:) then croſs it with two perpendiculers for the two contingent lines, at the moſt convenient

nient places, one in the upper part, and the other in the lower part of the Plain, as the two lines C E, and F G do ſhew, then by help of the inclination of Meridians, make the table for the hours in this manner; for this declination, it is 78:09, (Now every hour containing 15 degrees, and every quarter three degrees 45′ I find that the ſubſtile will fall on neer a quarter of an hour paſt five at night) therefore if you take 75, the meaſure of five hours out of 78. 9, there remaines 03. 09. for the firſt quarter from the ſubſtile next 12. Again, if you take 78. 09, the inclination of Meridians out of 78. 45, the meaſure of 5 hours one quarter, and there remaines 00. 36. for the firſt quarter on the other ſide of the ſubſtile, then by continual adding of 03. 45, to 03. 09, and to 00. 36, I make up the table as heer you ſee or elſe you may againſt 12, ſet down 78. 09, and then take out 3. 45, as often as you can, till you come to the ſubſtile, and then what

what the remainder wants of. 3.45, muſt be ſet on the other ſide of the ſubſtile, and 3. 45 added to that, till you come to as late as the ſun will ſhew on the Plain, as here you ſee to ¼ paſt 8.

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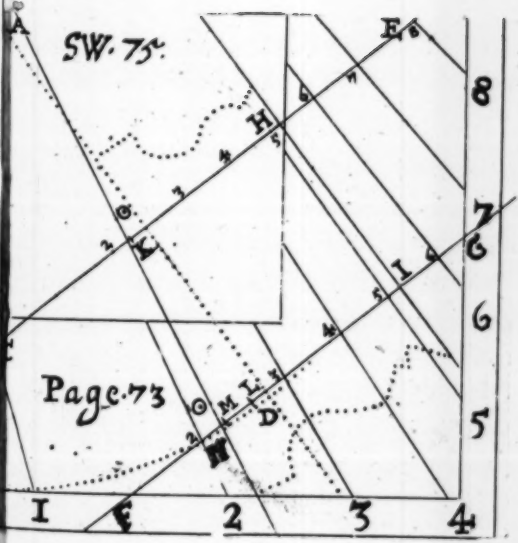
Then conſider what hours will be convenient to put on, alſo the two places moſt convenient for them two extreme hours: as for this Plain 8 at night, and 1 afternoon, will ſit beſt; and the two places I appoint for them ſhall

ſhall be at E, and C, in the upper contingent line. Then look in the table for the numbers of 8, and I finde it to be 41, 51, which ſought in a table of natural tangents will be found to be ·089567. And the number in the table for 1 is 63.09, whoſe natural number is found to be 197537. Or if you want thoſe tables, the line of Lines and Tangents, or a Scale made equal to the Radius of the tangents, will ſupply the ſame though you cannot ſee ſo many figures, yet to four figures will ſerve our turn very well, or elſe the artificial tangent on the edge ſhall ſhew the natural number in the line of numbers, reading it as a Scale of equal parts, and having due reſpect to the increaſe of the Radius; for if it be under 45, the number right againſt it, is the natural tangent; if above 45 meaſure from 45 to it, that extent aplyed from 1 in the numbers, giveth the natural number required. Add theſe two numbers 0896 and 19,

75, and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75, and they make 2 8 7 1 : which ſought in the tables will be found to be the Logarithm of the natural tangent of 70. 48. or if you take it off from your Scale, and meaſure it on the line of tangents you ſhall finde it reach to 70. 48, as before, then take the whole ſpace of your upper contingent from E to C, the two points for 8 and 1, and fit it in the parallel tangent of 70. 48 (and then the tangent of 45 ſhall be Radius, and the ſecant of the ſtiles height to the ſame Radius, ſhall be the ſtiles height on the contingent. (or the Radius before, laid at the nigheſt diſtance from H to ⊙,) then the ſector ſo ſet, take out the number for 1, out of the line of tangents, and lay it from C to H, and the number for 8, and lay it from E to H, and if your work be true they will meet, and that point H, is the true place of the ſubſtile: then draw HI parallel to A D, for the true ſubſtile, and the ſector ſo ſtanding lay off all the numbers in the table, taken

out of the tangents from H toward E, and C as the numbers direct, and note them points with 1, 2, 3, 4, 5, 6, 7, 8. Then lay the Radius H K, from I to L, on the other contingent line, (and making H I Radius, or the tangent of 45, lay off the tangent of the ſtiles height, from L to M 9. 16) then ſhall I M, be the other Radius, on the other contingent line, and I N the ſecant of 9. 16, at the Radius of I M, the place of the ſtiles height on this contingent line, being found more readily, by taking the Radius I M, at the nigheſt diſtance being about I ⊙, and H ⊙, then draw ⊖ ⊙ for the true height of the ſtile, being augmented to fit thoſe hours 8 and 1, and to fil the Plain ſo, that no room be loſt, then having drawn the ſtile, and ſet the ſector to the Radius, lay down all the numbers in the table, on this contingent line out of the line of tangents, from I both wayes: as the numbers direct, and mark every whole hour, with 1, 2, 3, 4, 5, 6, 7, 8

as before. Laſtly, lines drawn by theſe markes in the two contingent lines, ſhall be the hours and quarters required.

The ſtile or gnomon is to be erected right over the ſubſtile, to the angle of 9. 16, and augmented as much as from H to ⊙, and from I to ⊙, at the nigheſt diſtance from the point H and I, drawnin the ſubſtile line on the Plain, this way is as eaſy, ſpeedy, artificial and true, as any extant, (if your ſcales be true,) and improveth the Plain at the firſt, to the moſt poſſible beſt advantage that can be.

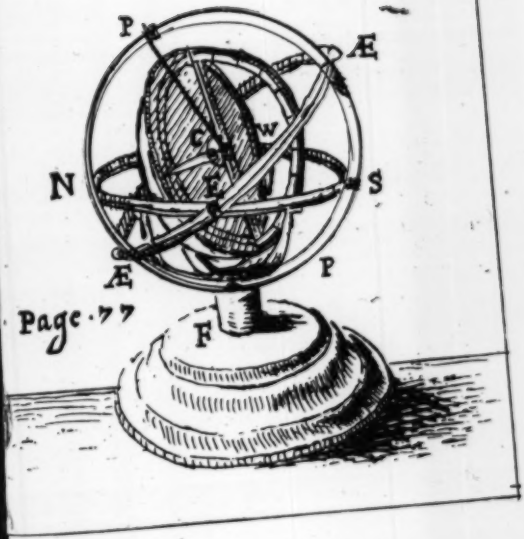
Note alſo, if in ſtriving to put as many hours as you can on the Plain, the ſum of the two natural numbers added together, comes to above 40000 : then you muſt reject ſomething of one of them, for they will not be comely nor convenient, nor far enough aſunder. I might have enlarged to declining, reclining plaines, but my intention is not to make a buſineſs of it, but onely to give a taſte

of the usefulness, and convenience of a Joynt-rule, as now it is improved.

An Advertisement relating to Dialling.

These directions are sufficient for any Horizontal, direct, and declining vertical Dials, but for all other, as East or West inclining and reclining, direct, or reclining and inclining, and declining polars; and all declining and inclining and reclining Plains, the perfect knowledge of their affections and scituations is very hard to conceive, but much more hard to remember by roat, or knowingly.

Therefore for the better help of the imagination to conceive aright of their affections, and setuations you may be furnished with an Instrument in brass, at the house of Mr. *Walter Hayes*, neer the Popes-head Tavern in *Morefields*, at the Sign of the *Cross-daggers*, or at the house of *John Brown*, at the Sign of the *Sun-Dial* in the *Minories*, or at Mr. *Henry Suttons* in *Thred-*



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Threadneedle-ſtreet behind the *Exchange*. Which Inſtrument being rightly made, you may rectifie to any latitude, and to any declination or reclination, and being ſo ſet, it will give the ſubſtile, ſtile, inclination of Meridians, and every hours Ark on the Plain by occular inſpection to half a degree, and ſhew you all the affections ſtraightway: howſoever ſituated, as which Pole is elevated, and which way applied, and what hours will be uſeful, *&c.*

A repreſentation of which inſtrument take in this place, let the circle E S W N, repreſent the Horizon S Æ P N the Meridian, Æ W Æ E the Equinoctial, P C P the Pole, being the points of an Axes made of thread, and paſſing through the center C W C E being ſhaddowed, repreſents the Plain, ſet to a declination, and to a reclination 45 degrees, F the foot that doth ſupport it; moreover the Plain hath an Arch fitted to it, to get the ſtiles height, and to ſet it

to any angle; alſo the Horizon and Plain is made to turn round, which could not well be expreſſed in this figure, or repreſentation of the inſtrument: a more liveley and eaſie help cannot likely be invented, and for cheapneſs the like may be in a half circle, or made of Paſt-board.

The uſe and application of which figure, I ſhall not now ſpeak of, partly becauſe of the facillity in the uſing thereof, and partly becauſe of the difficulty in deſcription thereof; and laſtly, whereſoever you ſhall buy the ſame, at either of the three places, the uſe will be taught you *gratis*.

Alſo note, that half of the Inſtrument may be made either in braſs, or paſtboard, and be made to fold down in a book, and perform the uſes thereof indifferently well, for many purpoſes, as to the Affections of Dials.

Then having diſcovered the affections, you may by the Cannons in the ſeventh Chapter of Mr. *Windgates Rule of proportion*, finde all the requiſites,

quiſites, and then to ſpeed the laying down the hours, you may do it by help of the tangent of 45, as you did in erect decliners; for after you have drawn the hours of 6, and three, or nine, and made a parallelogram by two lines parallel to 12, and one parallel to ſix, then making the diſtance from ſix to nine, or three in the line parallel to 12, a tangent of 45, and the diſtance from 12 to 9, or 3 in the parallel to 6, likewiſe a tangent of 45, in the ſector, and laying off 15, 30. 45, or the reſpective quarters from 6, and 12, in thoſe two lines, and they ſhall be the true points to draw the hour lines, by laying a ruler to them, and the center of the Dial; but for thoſe that have no centers, the rule of augmenting the ſtile in far decliners, ſerveth for theſe alſo.

CHAP. XVI

To finde a perpendicular altitude at one or two ſtations, and obſervations by by the degrees on the rule.

OPen the rule to his Angle of 60 degrees, then looking up to the top or point of altitude you would obſerve the height of, as you do when you take the Suns altitude, and note the degrees and parts the thread cuts, and write it down in chaulk or ink, that you forget it not.

Then meaſure from the place you ſtand to the foot or baſe of the object, (being right under the top of the object, whoſe height you would meaſure) in feet, yards, or any other parts.

Thirdly, conſider this being a right angled Plain triangle, if you have the angle at the top, the angle at the baſe is always the complement thereof.

Theſe

Theſe things being premiſed, the proportion holds, as the ſine of the angle oppoſite to the meaſured ſide, (or baſe) being the complement of the angle found, is to the baſe or meaſured ſide: ſo is the angle found, to the height required.

Always remember to adde the height of your eye from the ground, (at the time of taking the angle) to the altitude found.

For the operation of this, extend the compaſſes from the ſine of the complement of the Angle found to the number of the meaſured ſide, on the line of numbers that diſtance applied the ſame way, from the ſine of the Angle found, ſhall reach on the line of numbers to altitude required.

Example *at one ſtation.*

I open my rule, and hang on the thread and plummet on the center, and obſerving the Angle at C, I finde it to be 41. 45, and the Angle at B the complement of it 48. 15, and the

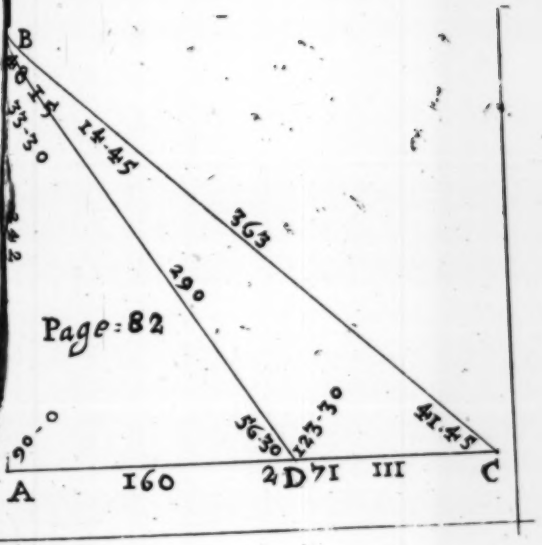
measure from C to A 271 feet: then the work being so prepared, is thus:

As the Sine of 48. 15,
Is to 271 *the measure of the side opposite to it:*
So is the Sine of the Angle 41. 45,
To 242 *the measure of the side* A B, *opposite to the Angle at* C, *the height required.*

Again, at the station D, 160 foot from A, I observe and finde the Angle D to be 56. 30, the Angle at A is the complement thereof, *viz.* 33. 30. This being prepared, I extend my Compasses from the line of 33. 30 to 160, on the line of numbers the same extent will reach from the line of 56.30, to 242 on the line of numbers, lacking a small fraction, with which I shall not trouble you.

An example at two stations.

But if you cannot come to measure to the foot of the object, then you must observe at two places: As suppose first at D, where as before the Angle


B
33-30
14-45
363
290
Page: 82
56-30
123-30
41-45
90-0
A
160
D
71
111
C

Angle is found 56. 30, whose complement is 33. 30, counting from the head of the Rule: Then I remove right backward to C, 111 feet, and observe the Angle counted from the head to be 48. 15, which is the angle at B, but the angle at C is 41. 45. Then the work is thus: first, you must take the angle at B at the first station, out of the angle at B, at the second station, and note the difference, then the rule runs thus:

As the Sine of the difference, which is the Angle C B D 14. 45,
Is to the side measured, viz. D C 111 *feet on the numbers:*
So is the sine of the Angle at C 41. 45,
To the measure of the side B C, *the hypothenusa, or measure from your eye to the top of the object,* viz. 290 *feet.*

Again for the second Operation.

As the sine of 90 *the right angle at* A,
Is to 290 *the hypothenusa* B D:

So

So is the ſine of 56. 30, *the Angle at the firſt ſtation* D,
To 242, *the Altitude* B A, *the thing required* ::
So alſo is the ſine of the Angle at B 33. 70, *the complement of* 56, 30.
To 160 *the diſtance from* D *to* A.

To perform the ſame by the line of ſines, drawn from the center on the flat-ſide, and the line of lines, or equal parts or inches in ten parts.

To work theſe or any other queſtions by the line of natural Sines and Tangents, on the flat-ſide, drawn from the center, it is but changing the terms, thus: As the meaſured diſtance taken out of the line of lines, or any ſcale of equal parts, is to the ſine of the angle, oppoſite to that meaſured ſide, fitted acroſs from one leg to the other, the Sector ſo ſtanding, take out the parallel ſine of the angle oppoſite to the enquired ſide, and that meaſure ſhall reach on the line of equal parts, to the meaſure of the Altitude requi-

Example as before.

Take out of the lines or inches 2. 71, and fit it in the ſine of 48. 15, acroſs from one legge to the other, which I call *A parral ſine*, (but when you meaſure from the center onwards the end, I call it *A latteral ſine*,) then take out the parallel ſine of 41. 45, and meaſure it on the line of inches, or equal parts, and it ſhall reach to 2 inches 42 parts, or 242, the Altitude required.

After the ſame manner may queſtions be wrought on the line of lines, ſines, or tangents alone, or any one with the other, by changing the Logarithmetical Canon from the firſt to the ſecond, or third, and the ſecond or third to the firſt or ſecond; as the caſe ſhall require, from a greater to a leſs, and the contrary; for the fourth is always the ſame; of which in the uſe of the Sector, by *Edmund Gunter*, you may finde many examples, to which I refer you.

Alſo without the lines of ſines either

ther natural or artificial, you may find altitudes, by putting the line of quadrat, or ſhadows, on the Rule as in a quadrant, then the directions in the uſe of the quadrat, page 146 of the *Carpenters Rule*, will ſerve your turn, which runs thus:

As 100 (or 50 according as it is divided) to the parts cut by the thread, ſo is the diſtance meaſured, to the height required; which work is performed by the line of numbers onely. Or again, As the parts cut, to 100 or 50: ſo is the height to the diſtance required. But when the thread falls on the contrary ſhadow, that is, maketh an Angle above 45, then the work is juſt the contrary to the former.

What is ſpoken here of taking of Altitudes, may be applied to the taking of diſtances; for if the Sector be fitted with a ſtaff, and a ball-ſocket, you may turn it either horizontal, or perpendicular, and ſo take any Angle with it, very conveniently and readily

readily by the ſame rules and directions as were given for the finding of Altitudes.

CHAP. XVII.

The uſe of certain lines for the menſuration of ſuperficial and ſolid bodies, uſually inſerted on Joynt-Rules for the uſe of Work-men, of ſeveral ſorts and kindes.

FIrſt the moſt general and received line for menſuration of Magnitudes, is a foot divided into 12 inches, and thoſe inches into 8, 10, 12, or more parts; but this being not ſo apt for application to the numbers, I ſhall not inſiſt of it here, but rather refer you to the *Carpenters Rule*; yet nevertheleſs thoſe inches, laid by a line of foot meaſure, doth by occular inſpection onely, ſerve to reduce foot meaſure to inches, and inches likewiſe to foot meaſure, and ſome other concluſions alſo.

1. As

1. As first, The price of any commodity at five score to the hundred, either tale or weight, being given, to finde the price of one in number, or one pound in weight.

As suppose at two pence half-peny a pound, (or one) I demand to what cometh the hundred weight, (or five-score,) counting so many pound to the hundred weight?

If you look for two inches and a half, representing two pence two farthings, right against it on the foot measure, you have 21 very near; for if you conceive the space between 20 and 21, to be parted into 12 parts, this will be found to contain ten of them, for the odde ten pence. But for the more certain computation of the odde pence, look how many farthings there is in the price of one pound, twice so many shillings, and once so many pence is the remainder, which if it be above 12, the 12 or 12s, being substracted, the remainder is the precise number of pence,

above

above the ſhillings there expreſſed; and on the contrary, at any price the C hundred, or 5 ſcore, to finde the price of one, or 1 l. As ſuppoſe at 40 s. the C. or 5 ſcore, look for 40 in the foot meaſure, and right againſt it in the inches, you have 4 inches, 3 quarters, and ¼ of a quarter, which in this way of account is 4 pence 3 farthings, and about a quarter of one farthing. Thus by the lines, as they are divided, it proceeds to 12 pence a pound; but if you conceive the inches to be doubled, and the foot meaſure alſo, you ſhall have it to 24 d. or 48 d. the pound, or one in tale, of any commodity. As at 18 d. a piece, or pound, the price comes to 7 l. 10 s. the C. for then every ten ſtrokes is 20s in the foot meaſure, and every inch is 2 pence, and every eighth one farthing.

2. Secondly, for the buying of Timbet at 50 foot to a Load, at any price the load, how much a foot.

Here in reſolving this, the inches are

are to be doubled, and the foot measure taken as it is: As at 40 shillings the Load, 40 in the foot measure stands right against 4 inches 3 quarters and better, which being doubled, is 9 d. 2 far. $\frac{1}{2}$ far. near, for the price of one foot; and on the contrary, at 5 d. a foot, is 41 s. 8 d. a load, &c.

3. For the great Hundred of 112 l. to the Hundred, let the space of 12 inches be divided into 112 parts, then the like rule holds for that also.

For the inches being divided into quarters, every quarter is a farthing, and every eighth half a farthing, and every division of the 112 is a shilling, and every alteration of a farthing in the price of a pound, makes a groat in the Hundred, as thus: At 3 pence a pound is 28 s. the C. At 3 d. 1 q. a pound, 30 s. and 4 d. the C. At 3 d. $\frac{1}{2}$ the pound, 32 s. 8 d. the C. At 3 d. 3 farthings, 35 s. the C. Thus you see that every fraction at a farthing advance, is 4 pence in the Hundred; but for any other account, as 3 pence far-

farthing half farthing, then count the fraction, as 1, 12th part of a ſhilling, and nearer you cannot come by a bare occular inſpection; but the price of the Hundred being given, the price of the pound you have as near by this occular inſpection, as any uſual Coin is reducable, *viz.* to the 32 part of a peny, or nigher if you pleaſe.

Again note here alſo, you may double, or quadruple the price: as to 24 d. or 48 d. the pound, or any price between. As for example: At 13 d. a pound, is 6 l. 1 s. 4 d. the C. At 32 d. or 2 s. 8 d. the pound, is 14 l. 19 s. the C. and the like by dupling and quadrupling the inches, and the 112 parts, that layeth by it.

4. Theſe lines of equal parts ſerve as Scales, for the protracting of any Draught of houſe or field, or the like; alſo for addition or ſubſtraction of any ſmall number.

5. Note that the line of foot meaſure, may be applied for the reducing of any odde fraction to a decimal fraction,

ction, as you may see it in page 64. of Mr. *Windgats Arithmetick* made easie.

2. *The use of the lines of decimal Timber and Board measure.*

The lines of decimal Timber and Board measure, are fitted to agree with the tenths, or foot measure, as those lines in the first chapter of the *Carpenters Rule*, are fitted to the inches, and the use of them is thus: And first for the decimal Board measure. Suppose a Board is 1 foot 50 broad, I look for 150 on that line, and from that place to the end of the Rule forwards, toward 100, so much in length must you have to make a foot of superficial or board measure.

2. Or else thus: If you apply the end of the Rule next 100, to one edge of the breadth of a board, or glass, then right against the other edge of the board, on that line of decimal board measure, you shall finde the 10ths and 100s, (or feet 10ths & 100) parts

parts of a foot, that you muſt have in length to make a foot ſuperficial at that breadth.

Example.

I come to a board and applying the upper end next 100, even to one edge of the board, the other reacheth to 0. 8 tenths, then I ſay that 8 tenths of a foot length at that breadth, makes a foot.

3. *The uſe of decimal Timber meaſure.*

The uſe of this is much like the Board meaſure, onely here you muſt have a reſpect to the ſquareneſs of the piece, and not to the breadth onely; for after you know how much the piece of timber or ſtone is ſquare, in feet and 100 parts, then look that number on the line of decimal Timber meaſure, and from thence to the end of the Rule, is the length that goes to make a foot of timber.

Exam-

Example.

At 14, or 1.40. parts of a foot ſquare, look the ſame on the rule, and from thence to the end where 40 is, is the length of a foot of Timber, at that ſquareneſs, being about 51 parts of a foot divided into a 100 parts.

5. *The uſe of the line of decimal yard meaſure, alſo running yard meaſure, according to the inches or decimal parts of a foot.*

The decimal yard meaſure, is nothing elſe but a yard or 3 foot divided into a 100 parts, and uſed in the ſame manner as the foot meaſure is, for if you take the length, and the breadth in that meaſure, and multiply it together, you ſhall have the content, in yards and 100 parts of a yard.

Example.

Suppoſe a peece of plaſtering is 4 yards 78 parts one way; and 7. 35 parts another way: being multiplied together makes 35 yards, and 9954. of 10000, which is very neer 36 yards.

5. But

5. But the decimal running yard measure is fitted to the foot measure, and the use is thus: Suppose a room is to be measured that is 7 foot 8 tenths high, and I would know how much makes a yard, at that breadth or height; look foot 7 f. 8 10ths on the line of decimal running yard measure, and the space on the rule, from thence to the end next 100 is the true length, that goeth to make up a yard of superficial measure, at that breadth or height.

But if the peece be between 4 foot 5 [10] broad, and 2 foot, then the table at the end of the line, will supply the defect: or you may change the terms, and call the length the breadth, and the contrary. But if it be under 2 foot broad, then if you do as you did with the board measure, you shall have your desire.

Example.

At 1 foot 3 10th broad, 6 foot 9 10ths make a yard.

6. But if the running yard measure be

be made to agree with the inches, then measure the height of the room in feet and inches, and if you take a pair of compasses, and measure from that place, to the end of the rule, then turn the compasses set at that distance as many times as you can about the room, so many yards is there in the room.

7. *The use of the line of decimal round measure, commonly called Girt-measure, which is when the circumference of a round Cillender, or piller given in inches or ten parts of a foot.*

First (for Girt-measure according to inches, being the most usual measure) measure how much the pillar is about, then look for the same number on the line of Girt-measure, and from thence to the end of the rule, is the length that goeth to make a foot of Timber.

But if it be under 30 inches about, then you must have above two foot in length, and then a table at the end of the line, or a repetition in another line

line, will ſupply the defect. But if the line of Girt-meaſure be divided according to foot meaſure, then uſe it as before, ſeeking the decimal part on the line, and from thence to the end is a foot.

8. *The uſe of a line of ſolid meaſure, by having the Diameter of a round piece given in inches, or foot meaſure.*

Take the diameter with a rule, or a pair of Callipers, and learn the meaſure either in inches, or foot meaſure according as your line of Diameter is divided. Then look for the ſame number on the line of Diameter, and from thence to the end of the rule forward, is the length that makes a foot of timber at that diameter (or meaſure crofs the end of the round piece of Timber or ſtone.)

The Tables of all the under meaſure for all theſe lines follow.

100th.	F. 1000		10	F. 1000 p.
1	100. 00			3. 848
2	50. 000			3. 706
3	33. 300			3. 570
4	25. 000			3. 450
5	20. 000	3	3	3. 332
6	16. 600			3. 217
7	14. 300			3. 115
8	12. 500			3. 025
9	11. 120			2. 940
1	10. 000		5	2. 850
1	9. 100		6	2. 780
2	8. 340		7	2. 700
3	7. 720		8	2. 628
4	7. 150		9	2. 560
5	6. 670		4	2. 500
6	6. 260			2. 440
7	5. 888			2. 382
8	5. 555			2. 336
9	5. 260			2. 273
2	5. 000			2. 223
	4. 760			2. 173
	4. 546			2. 127
	4. 350			2. 083
	4. 170			2. 042
5	4. 000		5	2. 000

Decimall Superficiall. M.

	F.1000.p.	01	F.1000.p.
	1.962		1.320
	1.923		1.304
	1.816		1.286
	1.850		1.268
	1.820	8	1.250
	1.785		1.237
	1.756		1.220
	1.726		1.207
	1.697		1.192
6	1.669		1.178
	1.640		1.164
	1.615		1.151
	1.589		1.138
	1.563		1.125
	1.538	9	1.112
	1.516		1.100
	1.493		1.087
	1.472		1.076
	1.450		1.063
7	1.430		1.052
	1.409		1.041
	1.391		1.030
	1.373		1.020
	1.353		1.011
	1.337	10	1.000

Decimal Solid under Measure.

	F. 1000. p.	10	F. 1000 p.
1	10000 . 000		14 . 805
2	2500 . 000		13 . 715
3	1100 . 000		12 . 780
4	630 . 000		11 . 916
5	400 . 000	3	11 . 125
6	277 . 900		10 . 415
7	200 . 430		9 . 760
8	150 . 660		9 . 125
9	120 . 350		8 . 625
1	100 . 0000		8 . 150
	82 . 800		7 . 700
	96 . 500		7 . 310
	59 . 390		6 . 900
	51 . 100		6 . 565
	44 . 500	4	6 . 250
	39 . 150		5 . 945
	34 . 650		5 . 664
	30 . 850		5 . 404
	27 . 750		5 . 465
2	25 . 000		4 . 938
	22 . 700		4 . 720
	20 . 675		4 . 530
	18 . 920		4 . 342
	17 . 400		4 . 162
	16 . 000	5	4 . 000

F. 1000. p.		01.	F. 100. p.
3 . 825			1 . 738
3 . 790			1 . 694
3 . 524			1 . 651
3 . 430			1 . 608
3 . 310		8	1 . 568
3 . 188			1 . 528
3 . 078			1 . 493
2 . 968			1 . 458
2 . 873			1 . 420
6 2 . 780			1 . 390
2 . 688			1 . 356
2 . 602			1 . 323
2 . 521			1 . 297
2 . 442			1 . 266
2 . 366		9	1 . 236
2 . 294			1 . 208
2 . 227			1 . 185
2 . 160			1 . 160
2 . 100			1 . 131
7 2 . 043			1 . 109
1 . 985			1 . 084
1 . 93			1 , 061
1 . 878			1 . 041
1 . 830			1 . 021
1 . 781		10.	1 . 000

Under Yard-measure for feet and inches from one inch to four feet six inches

F. In.	F. 1000.	F. In.	F. 1000.
1	108.000		3.850
2	54.000		3.720
3	36.000	6	3.600
4	27.000		3.482
5	21.600		3.373
6	18.000		3.271
7	15.420		3.175
8	13.520		3.085
9	12.000		3.000
10	10.300	3	2.922
11	9.820		2.842
1.	9.000		2.769
	8.320		2.710
	7.740		2.633
	7.201	6	2.572
	6.760		2.512
	6.350		2.455
6	6.000		2.400
	5.680		2.345
	5.400		2.298
	5.140	4	2.250
	4.906	1	2.203
	4.695	2	2.160
2	5.500	3	2.119
	4.320	4	2.073
	4.160	5	2.037
	4.000	9	2.000

Under yard measure according to Decimal or Foot measure

F. 10.	F. 1000 p.		F. 1000 p.
1	90.000	4	3.710
2	45.000	5	3.600
3	30.000	6	3.461
4	22.500	7	3.332
5	18.000	8	3.211
6	15.000	9	3.104
7	12.880	3	3.000
8	11.200	1	2.903
9	10.000	2	2.812
1	9.000	3	2.728
1	8.190	4	2.648
2	7.510	5	2.572
3	6.930	6	2.502
4	6.430	7	2.435
5	6.000	8	2.370
6	5.625	9	2.310
7	5.290	4	2.250
8	5.000	1	2.195
9	4.735	2	2.142
2	4.500	3	2.093
1	4.285	4	2.046
2	4.092	5	2.000
3	391 2		

Inc. about	*F. in.* 100.		*F. in.* 100
1	1809 .6.81	24	3. 1. 87
2	452.4.74	25	2.10.74
3	201 .0.77	26	2. 8 . 12
4	113 .1.18	27	2. 5 . 87
5	72.4.60	28	2. 3 . 70
6	50. 3.19	29	2. 1 . 83
7	37 . 3.22	30	2. 0 . 13
8	28. 4.00	31	1. 10.60
9	22. 4.09	32	1. 9 .21
10	18. 1.15	33	1. 7 :94
11	14. 11.46	34	1. 6 .78
12	12. 6.80	35	1. 5 .72
13	10. 8.09	36	1,4,75
14	9. 2.79	37	1.3,86
15	8 . 0.51	38	1,3,04
16	7.0.82	39	1,2,28
17	6.3 . 14	40	1,1,57
18	5.7 . 30	41	1,0,92
19	5.0 . 15	42	1,0,31
20	4.6 . 28	43	0,11,74
21	4.1 . 24	44	0,11,22
22	3.8 . 87	45	0,10,72
23	3.5 .04		

Under measure for the Diameter in Inches and quarters.

In. over	F. in 10		F. in 100
,	2930,5,00	,	4, 8, 31
,	73 2,1,00	,	4, 4, 06
,	326,0,10	,	4, 0, 27
1	183,3,80	7	3, 8, 89
,	118,2,16	,	3, 5, 85
,	81,6,00	,	3, 3, 10
,	59,1[illegible],24	,	3, 0, 61
2	45,10,9[illegible]	8	2,10, 36
,	36,2,41	,	2, 8, 31
,	29,3,93	,	2, 6, 44
,	24,3,86	,	2, 4, 73
3	20,4,40	9	2, 3, 15
,	17,4,25	,	1, 1, 70
,	15,0,00	,	1, 0, 37
,	13,1,86	,	1,11, 13
4	11,5,14	10	1, 9, 99
,	10,1,78	,	1, 8, 93
,	9,0,62	,	1, 7, 95
,	8,1,80	,	1, 7, 04
5	7,3,98	11	1, 6, 18
,	6,7,80	,	1, 5, 38
,	6,0,72	,	1, 4, 63
,	5,6,53	,	1, 3, 93
6	5,1,10	12	1, 3, 27
		13	1, 1, 02

A Table of the number of bricks in a rodd of Walling at any Feet high, from 1 to 20 for 1 and 1 ½

Feet high.	*at 1 brick thick.*	*at 1 brick & ½ thick*
1	176	264
2	352	528
3	528	792
4	704	1056
5	880	1320
6	1136	1704
7	1232	1848
8	1408	2112
9	1584	2376
10	1760	2640
11	1936	2904
12	2112	3168
13	2288	3432
14	2464	3696
15	2640	3960
16	2816	4224
16½	2904	4356
17	2992	4488
18	3168	4752
19	3344	5010
20	3520	5280

If

If you would have this Table for ½ a brick, take the half of the table for one brick. If for two bricks then double it. If for two and a ½ then ad both these together; if for three, double that for one brick and ½.

If you have any number of feet of brick work, at half a brick, one brick, or two bricks, or more, and you would reduce it to one brick and half, then say by the line of numbers as 1. 2. 4. 5 or 6 is to three, so is the number of feet at ½ 1. 2. 2 ½ or three bricks to the number of feet at one and ½.

The use of four scales, called Circumference, *Diameter*, *Square equal*, *Square inscribed* [illegible]

Suppose you have a circle whose diameter is 10 inches, or 10 feet: and to this circle you would finde the *Circumference*, or the side of a square equal, or inscribed, or having any one of the three, to finde the other three, do thus:

Take the measure of the Circumference

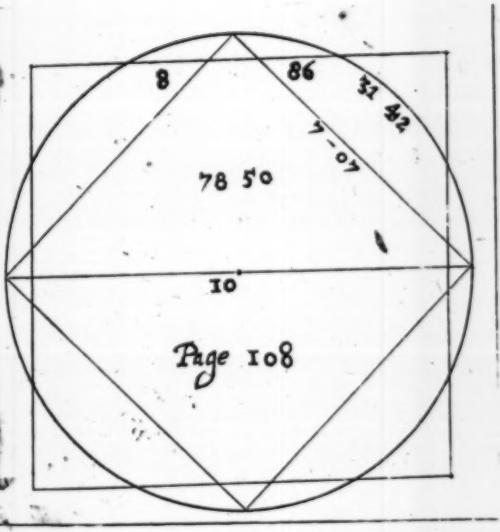
ference, Diameter, or either of the ſquares, which is firſt given, and open the compaſſes to the number of the given meaſure, in its reſpective ſcale: the compaſſes ſo ſet, if you apply it in the ſcale whoſe number you would know, you ſhall have your deſire.

Example.

Suppoſe a circle whoſe diameter is 10 inches, and to it I would know the *Circumference*, take 10 out of the diameter ſcale, and in the *Circumference* ſcale it ſhall reach to 31 42, and on the line of ſquare equal 8 86, and on ſquare inſcribed 7. 07. For illuſtration ſake, note the figure.

The uſe of the line to divide a circle into any number of parts.

Take the Semidiameter, or Radius of the circle between your compaſſes, and fit it over in ſix and ſix of the line of circles, then what number of parts you would have, take off from that point by the figure in the line of circles, and it ſhall divide the circle into



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into ſo many parts. As ſuppoſe I would have the former circle divided into nine parts, take the meaſure from the center to the circle as exactly as you can, fit that over in 6 and 6, then take out 9 and 9, and that ſhall divide it into ſo many parts; but if you would divide a wheel into any odde parts, as 55. 63. or 49 parts, you ſhall finde it an almoſt impoſſible thing, to take a part ſo exact that in turning about ſo many times, ſhall not miſs at laſt: to help which the parts the rule giveth ſhall fit you exact enough for all the odde parts, then the even will eaſie be had by dividing, therefore uſually the rule is divided but to 30 or 40 parts. So that for this uſe as the finding the ſide of an 8 or 10 ſquare piece, as the maſt of a ſhip, or a newel, or a poſt, this will very readily, and exactly help you.

CHAP.

CHAP XVIII.

The use of Mr. Whites *rule, for the measuring of Timber and Board, either by inches or foot measure.*

1. AND first for superficial or board measure, by the inches, the breadth and length being given in inches, and feet and parts, slide or set 12 on any one side, to the breadth in inches or parts on the other side, then just against the length found on the first side, where 12 was on the second side you shall have the content in feet, and 10ths, or 100 parts required. Which by the rules of reduction by the foot measure, you may reduce to inches and 8 parts.

Example.

At three inches broad, and 20 foot long, you shall finde it to be 5 foot just: but at 7 inches broad, and the same length it will come to 11 foot 7 10th fere, or 8 inches.

2. *The*

2. *The breadth being given in inches, to finde how many inches in length goes to make a foot of board or flat meaſure.*

Set 12 on the firſt ſide, to the breadth in inches on the ſecond ſide, then look for 12 on the ſecond ſide, and right againſt it on the firſt ſide, is the number of inches, that goes to make a foot Superficial, at that breadth.

Example.

At three inches broad you ſhall finde 48 inches to make a foot.

3. *To work multiplication on the ſliding, or* Whites *rule.*

Set one on the firſt ſide, to the multiplicator on the ſecond ſide, then ſeek the multiplicand on the firſt, and right againſt it on the ſecond, you ſhall finde the product.

Example.

If 9 be multiplied by 16, you ſhall finde it to be 144.

4. *To*

4. *To work diviſion on the ſame rule.*

Set the diviſor on the firſt ſide to one on the ſecond, then the dividend on the firſt, ſhall on the ſecond ſhew the quotient required.

Example.

If 144 be to be divided by 16, you ſhall finde the quotient to be 9.

3. *To work the rule of 3 direct.*

Set the firſt term of the queſtion, ſought out on the firſt line, to the ſecond term on the other, (or ſecond line:) then the third term ſought on the firſt line, right againſt it on the ſecond, you ſhall finde the fourth proportional term required.

Example.

If 15 yard $\frac{1}{2}$, coſt 37 s. 6 d. what coſt 17 $\frac{1}{4}$? *facit* 42 s. 10 d. 3 q. for if you ſet 15 $\frac{1}{2}$ right againſt 37 $\frac{1}{2}$, then look for 17 $\frac{1}{4}$ on the firſt line, (where 15 $\frac{1}{2}$ was found, and right againſt it on the ſecond line, is neer 42 the fractions

ſtions are all decimal, and you muſt reduce them to proper fractions accordingly

To work the rule of 3 reverſe.

4. Set the firſt term ſought out on the firſt line, to the ſecond being of the ſame denomination or kind to the ſecond line, or ſide. Then ſeek the third term on the ſecond ſide, and on the firſt you ſhall have the anſwer required. *Example.*

5. If 300 maſons build an edifice in 28 days, how many men muſt I have to perform the ſame in ſix days, the anſwer will be found to be 1400.

6. To work the double rule of 3 direct.

This is done by two workings: As thus for Example.

If 112 l. or 1 C. weight, coſt 12 pence the carraiage for 20 miles, what ſhall 6 C. coſt, 100 miles? Say firſt by the third rule laſt mentioned, as 1 C. weight to 12, ſo is 6 C. weight to 72 pence, ſecondly ſay if 6 C. coſt 72 pence or rather

6 s.

6 s, for 20 miles? what ſhall 100 miles require? the anſwer is 30 s. for if you ſet 20 againſt 6 then right againſt 100 is 30, the anſwer required.

The uſe of Mr. Whites *rule in meaſuring Timber round, or ſquare, the ſquare or girt being given in inches, and the length in feet and inches.*

1. The inches that a piece of Timber is ſquare, being given: to finde how much in length makes a foot of Timber, look the number of inches ſquare on that ſide of the Timber line, which is numbred with ſingle figures from 1 to 12, and ſet it juſt againſt 100 on the other or ſecond ſide, then right againſt 12 at the lower, (or ſome times the upper) end, on the firſt line, in the ſecond you have the number of feet and inches required.

Example. At 4 ½ inches ſquare, you muſt have 7 foot 1 inch ½ to make a foot of Timber. But if it be above 12 inches ſquare, then uſe the ſixth Problem of the 5th chapter of the *Carpenters*

gentera Rule, with the double figured ſide and Compaſſes.

2. But if it be a round ſmooth ſtick, of above 12 inches about, and to it you would know how much in length makes a true foot, then do thus. Set the one at the beginning of the double figured ſide, next your left hand, to the feet and inches about, counted in the other ſide, numbred with ſingle figures from 1 to 12, then right againſt three foot ſix $\frac{1}{2}$ inches, in the ſingle figures ſide next the right hand, you have in the firſt ſide the number of feet, and inches required.

Example. A piece of 12 inches about, requires 11 f 7 in: *fere* to make a foot. Again a piece of 15 inches about, muſt have 8 foot $\frac{1}{2}$ an inch in length, to make a foot of timber.

3. But if you would have it to be equal to the ſquare, made by the 4th part of a line girt about the piece, then inſtead of three foot $6\frac{1}{2}$ inches make uſe of four foot, and you ſhall have your deſire.

4. The

4. The side of a square being given in inches, and the length in feet, to find the content of a piece of timber.

If it be under 12 inches square then work thus: set 12 at the beginning or end of the right hand side, to the length counted on the other side, then right against the inches square on the right side is the content on the left side

Example. At 30 foot long, & 9 inches square, you shall find 16 foot 11 inches for the working this question, 12 at the end must be used.

But if it be above 12 inches square, then set one at the beginning, or 10 at the end of the right hand side, to the length counted on the other side, then the number of inches or rather feet and inches, counted on the first side, shall shew on the second the feet and parts required.

Example. At 1 f. 6 inch. square, and 30 foot long, you shall finde 67 feet and about a $\frac{1}{2}$.

5. To measure a round piece by having the length, and the number of inches

inches about, being a ſmooth piece, and to meaſure true, and juſt meaſure, then proceed thus:

Set 3 f. 6 ½ inches on the right ſide, to the length on the other ſide, then the feet and inches about, on the firſt ſide, ſhall ſhew on the ſecond or left, the content required. As at 20 inches about, and 20 foot long, the content will be found to be about 4 foot 5 inches.

But if you give the uſual allowance, that is made by dupling the ſtring 4 times, that girts the piece: then you muſt ſet 4 foot on the right ſide, to the length on the other, then at 1 foot 8 inches about, the laſt example you ſhall finde but three foot 6 inches.

6. Laſtly, if the rule be made fit for foot meaſure, onely then the point of 12 is altogether neglected, and one onely made uſe of as a ſtanding number: and the point at three foot 6 ½ will be at three foot 54 parts, and the four will be the ſame, and the ſame directions

directions in every respect, serve th turn. And because I call it Mr. *White* rule, being the contriver thereof, according to feet and inches, I have therefore fitted these directions accordingly, and there are sufficient to the ingenious practitioner.

CHAP. XIX.

Certain Propositions to finde the hour and the Azimuth, by the lines on th Sector.

PROP. 1.

HAving the latitude, and comple ments of the declination, an Suns altitude, and the hour fro noon, to finde the Suns Azimuth, t that time.

Take the right sine of the comple ment of the Suns altitude, and mak it a parallel sine in the sine of th hour from noon, (counting 15 degree for an hour, and 1 degree for fou minutes) counted from the center.

Th

The Sector ſo ſet, take the right ſine of the complement of the declination, and carry it parallel till the compaſſes ſtay in like ſines, and the ſine wherein they ſtay ſhall be the ſine of the Azimuth required.

Or elſe thus:

Take the right ſine of the declination, make it a parallel in the coſine of the Suns altitude, then take the parallel ſine of the hour from noon, and it ſhall be the latteral or right ſine of the Azimuth from the ſouth required. If it be between ſix in the morning, and 6 at night; or from the north, if it be before or after ſix: and ſo likewiſe is the Azimuth.

PROP. 2.

Having the Azimuth from ſouth or north, the complement of the Suns altitude, and declination, to finde the hour.

Take the latteral, or right ſine of the complement of the Suns altitude, make it a parallel in the coſine of the declination: the ſector ſo ſett, take out the

the parallel sine of the Azimuth, and measure it from the center, and it shall reach to the right sine of the hour from noon required. Or else as before.

As the right sine of the complement of the Suns declination: is to the parallel sine of the Azimuth, so is the right sine of coaltitude, to the parallel sine of the hour from noon, counting as before.

PROP. 3.

Having the complements of the latitude, Suns altitude, and declination. to finde the Suns Azimuth from the north part of the horizon.

1. First of the complement of the latitude, and Suns present altitude finde the difference.

2. And secondly count it on the line of sines from 90 toward the center.

3. Take the distance from thence, to the sine of the Suns declination; but note when the latitude and declination differ, as in winter you must count the declination beyond the center,

ter, and you must call it the Suns distance from the pole.

4. Fourthly, make that distance a parallel line in the complement of the latitude.

5. Fifthly, then take out the parallel line of 90.

6. And sixthly, make it a parallel line in the coaltitude.

7. Seventhly, then the sector so set, take out parallel, Radius, or line of 90.

And eighthly, measure it on the line of lines from 90 towards, (and if need be beyond) the center: and it shall reach to the versed line of the Suns Azimuth from the north, or if you count the other way from the south, note that in working of these, if the line of lines be too big, then you have two or three smaller lines on the rule, where on to begin and end the work.

Example.

Latitude 51. 32, Declination 18. 30, Altitude 48. 12, you ſhall finde the Azimuth to be 130 from the North, or 50 from the South.

PROP. 4.

Having the complements of the latitude and declination, or Suns diſtance from the Pole, and the Suns altitude given, to finde the hour from East or Weſt, or elſe from noon.

1. Firſt of the complement of the latitude, and Suns diſtance from the Pole, finde the difference.

2. Count this from the ſine of 90 toward the center.

3. Take the diſtance from thence to the ſine of the Suns altitude.

4. Make that diſtance a parallel ſine of the complement of the latitude.

5. Take out the parallel ſine of 90 degrees, and

6. Make that a parallel ſine in the codeclination, then

7. Take out the parallel ſine of 90 again, and

8. Mea-

8. Measure it from the sine of 90 toward the center, and it shall shew the versed sine of the hour from the North, or the sine of the hour from East or West; or if you reckon from 90, the hour from noon required.

Example.

Latitude 51. 32, Declination North 20. 14, Altitude 50. 55, you shall finde the hour from the North to be 10 houres, or 10 a clock in the forenoon, or 4 hours past 6, or two short of noon, according to each proper reckoning.

PROP. 5.

Having the latitude, the complement of the Suns declination, the Suns present altitude, and Meridian altitude for that day, to finde the hour.

Make the lateral secant of the latitude, a parallel sine in the codeclination, then take the distance from the Suns Meridian altitude, to his present altitude, and lay it from the

cer on both sides of the line of sines, and take the parallel distance between those two points, and measure it from 90 on a line of sines, of the same Radius the secants be, (as the small adjoyning line is,) and it shall shew the versed sine of the hour from noon, or the right sine before or after 6, towards noon or night.

PROP. 6.

Having the Latitude, Declination, and Suns Altitude, to finde the Suns Azimuth.

Take the latteral secant of the latitude, and make it a parallel in the complement of the Altitude:

Then take the distance, between the sum of the complements of the Colatitude, and altitude, (if under 90, the sum of the Suns declination, and lay it from the center on the line of sines, that parallel distance taken, and measured on the sines (of the same Radius the secant was) from 90, shall shew the versed sine of the Azimuth from noon.

But

But if the ſum of the colatitude, and coaltitude exceed 90, then take the exceſs above 90, out of the natural ſine from the center toward 90, and add that to the ſine of the Suns declination towards 90, and then the parallel diſtance between thoſe two points, ſhall be the Azimuth required, from noon,

But when the latitude and declination are unlike, as with us (in the northern parts) in winter, then you muſt take the declination out of the exceſs, or the leſſer out of the greater, and lay the reſt from the center, and the parallel diſtance, ſhall be verſed ſine of the Azimuth from noon.

Example.

At 18 15 altitude, latitude 51 32, declination 13 15 South.

The ſum of the colatitude, and the coaltitude is 109. 37, then count the center for 90, the right ſine of 10 for a 100 and 19 for 109, and 37 minutes forwarder, there ſet the point of the Compaſſes, then take from thence to

the right ſine of the declination, and lay this diſtance from the center on the line of ſines, and the parallel ſpace between, is the verſed ſine of the Azimuth required.

PROP. 7.

Having the length of the ſhaddow of any object ſtanding perpendicular, and the length of that object, to finde the altitude.

Take the Tangent of 45, and make it a parallel in the length of the ſhaddow in the line of lines, then the parallel diſtance between the length of the object that caſts the ſhaddow, taken from the line of lines, and meaſured on the line of tangents from the center, ſhall reach to the Suns altitude required.

Example.

If the object be 40 parts long, and the ſhaddow 80 parts, the altitude will be found to be 26. 35. But if you have the altitude, and ſhaddow, and would know the height of the object, then work thus:

Take

Take the length of the ſhaddow out of the line of lines, or any other equal parts, and make it a parallel tangent of 45, then take out the parallel tangent of the Suns altitude, and meaſure it on the line of lines, (or the ſame equal parts.) and it ſhall ſhew the length of the object that cauſed the ſhaddow: the ſame rule doth ſerve in taking of altitudes by the rule, as in the 18 chapter, accounting the meaſure from the ſtation to the object, the length of the ſhaddow, and the Suns altitude, the angle at the baſe.

PROP. 8.

To finde the Suns riſing and ſetting in any latitude.

Take the latteral cotangent of the latitude, make it a parallel in the ſines of 90 and 90, then take the latteral tangent of the Suns declination, and carry it parallel in the ſines till it ſtay in like ſines, that ſine ſhall be the aſentional difference between ſix, and the time of riſing before or

after 6, counting 15 degrees to an hour.

PROP. 9.

To finde the Amplitude in any latitude.

Take the latteral ſine of 90, and make it a parallel in the coſine of the latitude, then the parallel ſine of the declination, taken and meaſured in the line of ſines from the center, ſhall give the amplitude required.

PROP. 10.

To finde the Suns height at ſix in any latitude.

Take the lateral or right ſine of the declination, and make it a parallel in the ſine of 90, then take out the parallel ſine of the latitude, and meaſure it in the line of ſines from the center, and it ſhall reach to the altitude required.

Note in working of any of theſe Propoſitions, if the ſines drawn from the center, prove too large for your Compaſſes, or to make a parallel ſine

or Tangent to a ſmall number of degrees, then you may uſe the ſmaller ſine or tangent adjoyning, that is ſet on the Rule, and it will anſwer your deſire. And note alſo in theſe Propoſitions, the word *right*, or *latteral ſine* or *tangent*, is to be taken right on from the center or beginning of the lines of ſines, or tangents; and the word *parallel* always acroſs from one leg to the other.

PROP. 11.

To finde the Suns height at any time, in any latitude.

As the right Sine of 90,
Is to the parallel cotangent of the latitude:
So is the latteral or right Sine of the hour from 6,
To the parallel tangent of a fourth ark; which you muſt ſubſtract from the ſuns diſtance from the Pole, and note the difference. Then,
As the right of the latitude,
To the parallel coſine of the fourth ark:

So is the parallel cosine of the remainder,
To the latteral sine of the Altitude required.

PROP. 12.

To finde when the Sun shall come to due East, or West.

Take the tangent of the latitude from the smaller tangents, make it a parallel in the Sine of 90, then take the latteral tangent of the declination from the smaller tangents, and carry it parallel in the Sines, till it stay in like Sines, and that Sine shall be the Sine of the hour required from 6.

PROP. 13.

To finde the Suns Altitude at East or West (or Vertical Circle.)

As the latteral sine of declination,
Is to the parallel sine of the latitude:
So is the parallel sine of 90,
To the latteral sine of the Altitude required.

PROP:

PROP. 14.

To finde the Stiles height in upright declining Dials.

As the right Sine of the complement of the latitude,
To the parallel sine of 90:
So the parallel sine complement of the Plains declination,
To the right sine of the Stiles elevation

PROP. 15.

To finde the Substiles distance from the Meridian.

As the lateral tangent of the colatitude,
To the parallel sine of 90:
So the parallel sine of the declination,
To the latteral tangent of the Substile from the Meridian.

PROP. 16.

To finde the Inclination of Meridians.

As the latteral tangent of the declination,
To the parallel sine of 90:

So

So is the parallel sine of the latitude,
To the latteral cotangent in the inclination of Meridians.

PROP. 17.

To finde the hours distance from the Substile in all Plains.

As the latteral tangent of the hour from the proper Meridian,
To the parallel sine of 90 :
So is the parallel sine of the Stiles elevation,
To the latteral tangent of the hour from the substile.

PROP. 18.

To finde the Angle of 6 from 12, in erect Decliners.

As the latteral tangent of the complement of the latitude,
To the parallel sine of the declination of the Plain:
So is the parallel sine of 90:
To the latteral tangent of the Angle between 12 *and* 6.

Thus

Thus you ſee the natural Sines and Tangents on the Sector, may be uſed to operate any of the Canons that is performed by Logarithms, or the artificial Sines and Tangents, by changing the terms from the firſt to the third, and the ſecond to the firſt, and the third to the ſecond, and the fourth muſt always be the fourth, in both workings being the term required.

CHAP. XX.

A brief deſcription, and a ſhort touch of the uſe of the Serpentine-line, or Numbers, Sines, Tangents, and verſed ſine contrived in five (or rather 15) turn.

1. FIrſt next the center is two circles divided one into 60, the other into 100 parts, for the reducing of minutes to 100 parts, and the contrary.

2. You have in ſeven turnes two inpricks, and five in diviſions, the firſt Radius

Radius of the fines (or Tangents being neer the matter, alike to the firſt three degrees,) ending at five degrees and 44 minutes.

3. Thirdly, you have in 5 turns the lines of numbers, fines, Tangents, in three margents in diviſions, and the line of verſed fines in pricks, under the line of Tangents, according to Mr. *Gunters* croſs ſtaff: the fines and Tangents beginning at 5 degrees, and 44 minutes where the other ended, and proceeding to 90 in the fines, and 45 in the Tangents. And the line of numbers beginning at 10, and proceeding to 100, being one entire Radius, and graduated into as many diviſions as the largeneſs of the inſtrument will admit, being from 10 to 50 into 50 parts, and from 50 to 100 into 20 parts in one unit of increaſe, but the Tangents are divided into ſingle minutes from the beginning to the end, both in the firſt, ſecond, and third Radiuſſes, and the fines into minutes; alſo from 30 minutes

minutes to 40 degrees, and from 40 to 60, into every two minutes, and from 60 to 80 in every 5th minute, and from 80 to 85 every 10th, and the reſt as many as can be well diſcovered.

The verſed ſines are ſet after the manner of Mr. *Gunters* Croſs-ſtaff, and divided into every 10th minutes beginning at 0, and proceeding to 156 going backwards under the line of Tangents.

4. Fourthly, beyond the Tangent of 45 in one ſingle line, for one turn is the ſecants to 51 degrees, being nothing elſe but the ſines reitterated beyond 90.

5. Fifthly, you have the line of Tangents beyond 45, in 5 turnes to 85 degrees, whereby all trouble of backward working is avoided.

6. Sixthly, you have in one circle the 180 degrees of a Semicircle, and alſo a line of natural ſines, for finding of differences in ſines, for finding hour and Azimuth.

7. Se-

7. Seventhly, next the verge or outermoſt edge is a line of equal parts to get the Logarithm of any number, or the Logarithm ſine and Tangent of any ark or angle to four figures beſides the carracteriſtick.

8. Eightly and laſtly, in the ſpace place between the ending of the middle five turnes, and one half of the circle are three prickt lines fitted for reduction. The uppermoſt being for ſhillings, pence, and farthings. The next for pounds, and ounces, and quarters of ſmall *Averdupoies* weight. The laſt for pounds, ſhillings, and pence, and to be uſed thus: If you would reduce 16 s. 3 d. 2 q. to a decimal fraction, lay the hair or edge of one of the legs of the index on 16. 3½ in the line of l. s. d. and the hair ſhall cut on the equal parts 81 16; and the contrary, if you have a decimal fraction, and would reduce it to a proper fraction, the like may you do for ſhillings, and pence, and pounds, and ounces.

The

The uſes of the lines follow.

As to the uſe of theſe lines, I ſhall in this place ſay but little, and that for two reaſons. Firſt, becauſe this inſtrument is ſo contrived, that the uſe is ſooner learned then any other, I ſpeak as to the manner, and way of uſing it, becauſe by means of firſt, ſecond, and third radiuſſes, in ſines and Tangents, the work is always right on, one way or other, according to the Canon whatſoever it be, in any book that treats of the Logarithms, as *Gunter*, *Wells*, *Oughtred*, *Norwood*, or others, as in *Oughtred* from page 62 to 107.

Secondly, and more eſpecially, becauſe the more accurate, and large handling thereof is more then promiſed, if not already performed by more abler pens, and a large manuſcript thereof by my *Sires* meanes, provided many years ago, though to this day not extant in print; ſo for his ſake I claiming my intreſt therein, make bold to preſent you with theſe

few

few lines, in order to the use of them: And first note.

1. Which soever of the two legs is set to the first term in the question, that I call the first leg always, and the other being set to the second term, I call the second leg.

2. Secondly, if one be the first or second term, then for the better setting the index exactly, you may set it to 100, for the error is like to be the least neerest the circumference.

3. Thirdly, be sure you keep a true account of the number of turnes between the first and second term.

4. Fourthly, observe which way you move, from the first to the second term. To keep the like from the third to the fourth, except in the back rule of three, and in such cases as the Canon requires the contrary.

5. Fifthly in multiplication, one is always the first term, and the multiplycator or multiplycand the second, and the product always the fourth. Also note that in multiplycation the pro-

product of two numbers multiplyed, ſhall be in as many places as both the multiplycator, and multiplycand, except the leſt of them, be leſs then the two firſt figures of the product; moreover, for your more certain aſſinging of the two laſt figures of four or ſix, which is as many as you can ſee on this inſtrument, multiply the two laſt in your minde, and the product ſhall be the figure, as in page 28 of the *Carpenters Rule.*

6. In diviſion, the multiplicator is always the firſt term, and one the ſecond, the dividend the third, and the quotient the fourth; alſo the quotient ſhall have as many figures as the dividend hath more then the diviſor, except the firſt figures of the diviſor be greater then the dividends, then it ſhall have one leſs. Alſo note, the fraction after diviſion, is a decimal fraction, and to be reduced as before.

7. Note carefully whether the fourth proportional ought to be a greater or a leſs, and reſolve accordingly,

dingly, and note if one cometh between the third and fourth term, then must the fourth be raised a Radius or a figure more, and be careful to set the hairs exactly over the part representing the number or minutes of any degree.

8. Always in direct proportion, and Astronomical calculation, set the first leg to the first term, and the second leg to the second term, and note how many circles is between, then set the first leg to the third term, and right under the second leg, the same way, and so many turnes between the third and fourth, is always the fourth term required.

Example.

As 1, to 47, so is 240, to 11280. As the sine of 90, to 51 degrees 30 minutes, so is the sine of 80 to 50.26. And so of all other questions according to their respective Canons by the Logarithms in other books as in Mr. *Oughtreds Circles of Porportions*, from page 62 to 107, and others.

Here

Here followeth the working of certain Propoſitions by the Serpentine-line.

Thoſe that I ſhall inſert, are onely to ſhew the manner of working, and knowing of that once, all the Canons for all manner of queſtions, either in Arithmetick, Geometry, Navigation, or Aſtronomy, by any other Author, as Mr. *Gunter*, Mr. *Oughtred*, Mr. *Windgate*, Mr. *Norwood*, or others, may be ſpeedily reſolved, and as exactly as by the Tables, if the inſtrument be well and truly made. And firſt for the hour, according to *Gunter*.

PROP. 1.

Having the Latitude, Declination, and the Suns Altitude, to finde the hour.

Add the complement of the altitude, the complement of the Suns preſent altitude, and the diſtance of the Sun, from the elevated Pole together, and note their ſum, and half ſum, and find the difference between their half ſum

and

and the complement of the Suns present altitude, then work thus: for 36 42 degrees high, at 23. 32 declination, lat. 51. 32.

Lay the first leg, *viz.* that next your right hand being here most convenient, on the Sine of 90, keeping that fixed there, lay the other leg to the cosine of the latitude, *viz.* 38. 28. and note the turns between, which here is none between, but it is found in the next over it, then set the first leg to the Sine of 66, 28, the suns distance from the Pole, and in the circle just over it you shall have the Sine of 34. 47. for the fourth Ark or Sine.

Then in the second Operation.

Set the first or left leg to the sine of 34. 47. of the fourth Sine last found, then keeping that fixed there, set the other leg to the Sine of the half sum, *viz.* 79. 37. then remove the first leg to the Sine of the difference between the half sum, and the coaltitude, *viz.*

25.

25. 49. and then in the next circle, the other leg ſhall ſhew the Sine of 48. 34. whoſe half diſtance toward 90, being found by the Scale of Logarithms on the outermoſt circle, will diſcover the Sine of an Ark, whoſe complement being doubled, and turned into time (by counting 15 degrees to an hour) will give the hour required; but by help of the verſed Sines all this trouble is ſaved; for when the index or ſecond leg cuts the Sine of 48. 34. at the ſame inſtant it cuts the verſed Sine of 60, the hour from noon required, being 8 in the morning, or 4 in the afternoon, at 23. 32. of declination, in the latitude of 51. 32.

PROP. 2.

To work the ſame another way, according to Mr. *Collins*.

The

The Latitude and Declination given, to finde the Suns height at 6 a clock, Dec. 23.31. *Lat.* 51. 32.

Lay the left leg on the Sine of 90, and the other to the Sine of 23. 32, and you ſhall finde one turn between upwards, then the firſt leg laid on the Sine of the latitude 51, 32, the other leg ſhall ſhew the Sine of 18. 3. (in the ſecond circle above 51, 32.) for the Suns height at 6 required, and this is fixed for one day.

Then in ſummer time, or north declinations, by help of the line of natural ſines, in the ſecond line, finde the difference between the Suns preſent altitude, and the latitude at 6, but in Winter or Southern (ſigns or) declinations, addthe two altitudes together, in this manner. Lay one leg of the index to the natural ſine of the altitude at 6, and the other to the altitude propoſed, the two legs ſo ſet, bring one of them (*viz.* the right) to the beginning of the line of natural

ſines

ſmes, and the other ſhall ſtay at the difference required, but in Winter ſet one leg to the beginning of the ſines, and open the other to the height at 6, or rather depreſſion under the Horizon at 6, (which is all one at like declinations, North and South) then ſet the firſt leg to the preſent altitude of the Sun, and the other ſhall ſhew the Sine of the ſum of both added together; which ſum or difference is thus to be uſed:

Lay the left leg to the Coſine of the declination, and the other to the ſecant of the latitude, counted beyond 90, as far as the ſecant of 9, 40; or rather lay the left leg on the Coſine of the latitude, and the other to the ſecant of the ſuns declination, then the firſt leg laid on the ſine of the ſum in winter, or difference in ſummer, ſhall cauſe the other leg to fall on the ſine of the hour from 6, toward noon in winter and ſummer, except the altitude in ſummer be leſs then the altitude at 6, then it is the

hour from 6, toward mid-night.

PROP. 3.

Having the latitude, Suns altitude and declination, to finde the Suns Azimuth from east or west. Lat. 51. 32. *Declin.* 23. 30. *Alt.* 49 56.

First you must get the Suns altitude, or depression in the vertical Circle by this Cannon. Lay the first leg to the sine of the latitude, and the second to the sine of 90, and you shall finde them both to be on the same line, then the first leg laid on the sine of the declination, shall cause the second (being carried with the first, without moving the Angle first set) to fall on the sine of 30. 39. the Suns altitude in the Vertical Circle; with which you must do, as you did before with the altitude at 6, and the present altitude, to finde the sum and difference by help of the line of natural Tangents, then this proportion holds.

Lay the first leg to the cosine of the Al-

Altitude, (by counting the Altitude from 20) and the ſecond leg to the tangent of the latitude, and obſerve which way, and the turns between; then the firſt leg removed and laid to the ſine of the ſum (before found) in winter, or the difference in ſummer, ſhall cauſe the ſecond leg to fall on the ſine of the Azimuth of the Sun, from eaſt or weſt toward noon, if winter; and alſo in ſummer, when the Suns altitude is more than his altitude at the Vertical Circle; but if leſs from the eaſt or weſt, toward north or mid-night meridian: Thus in our Example, it will be found to be the ſine of 30 degrees, or 60 from the ſouth, the ſine of the difference being found to be 14. 49.

PROP. 4.

To finde the Azimuth, according to Mr. Gunter, *by having the Latitude, Suns Altitude, and Declination given.*

Firſt by the Suns declination get his

distance from the Pole, which in summer or North declinations, is always the complement of the declination, (likewise in south latitudes, and south declinations) but when the latitude and declination is unlike, then you must adde 90 to the declination, and the sum is the distance from the elevated Pole. Having found the distance from the Pole, adde that and the complement of the latitude, and Suns altitude together, finde the difference between their half sum, and the Suns distance from the Pole, then the proportion will be thus, as in this Example: 13 Declination, 41. 53. Alt. Lat. 51. 32.

Lay one leg on the sine of 90, and the other to the sine of 38,28, being so set, remove the first leg to the sine complement of the altitude 48. 07. and the second legg shall fall on a fourth sine, which will be found to be 27. 36. then set the first or left leg to 27. 36. the fourth sine, and the second to 81. 47. the sine of the half

half ſum, then removing the firſt leg to the ſine of the difference, ſhall cauſe the ſecond to ſhew two circles lower, the verſed ſine of 130, the Azimuth required, being counted from the North part of the horizon, whoſe complement to 180 from the South is 50 degrees.

Two other Canons to finde the hour of the day, and Azimuth of the Sun, by one operation, by help of the natural ſines: and firſt for the hour.

Having the latitude, the Suns Meridian, and preſent altitude, and declination, to finde the hour from noon.

Firſt lay one leg to the Meridian altitude, in the line of natural ſines, and the other to the ſine of the altitude in the ſame line, then bring the right leg to the beginning of the line of ſines, and the other ſhall ſhew the difference, which difference you muſt keep.

Then lay one leg on the coſine of the declination, and the other on the ſecant

ſecant of the latitude, and note the turnes between, or rather lay the firſt leg to the coſine of the latitude, and the other to the ſecant of the declination, then the legs being ſo ſet, bring the firſt or left leg to the ſine of the difference firſt found, and the other leg ſhall ſhew the verſed ſine of the hour from noon, if the verſed ſines had been ſet thus, *i. e.* the verſed ſine of 90, againſt the ſine of 90, as in ſome inſtruments it is: But to remedy this defect, do thus: keep the right leg there, and open the other to the verſed ſine of 0. or ſine of 90, and note the turnes between, then lay the leg that was on the ſine of 90, (or verſed ſine of 0,) to the verſed ſine of 90, and the other leg ſhall ſhew the verſed ſine of the hour from noon, counting from 90.

Example.

At 45 13 degrees altitude, declination North 23 32. latitude 51 32, the Meridian altitude is 62, (being found by adding colatitude, and declina-

clination together, and in ſouthern declinations by ſubſtraction.) Then the natural ſine of 45.42, taken from 62, ſhall be the ſine of 9. 38. then as the coſine of the latitude 38. 28, is to the ſecant of declination 23.32, ſo is the ſine of 9. 38. to the (ſine of 17. 05) or verſed ſine of 45, if they were placed and numbred, as in ſome inſtruments they be: but to help it in this, ſay: as the verſed ſine of 0, is to the verſes of 114. 26, ſo is the verſed ſine of 90, to the verſed ſine of 135, whoſe complement to 180 is the angle or hour from noon required.

Secondly, for the Suns Azimuth.

Having the latitude, declination, and Suns altitude, to finde the Azimuth from South or North.

Firſt add the complements of the coaltitude and colatitude together, then if the ſum be under 90, take the diſtance between the coſine of it, and the ſine of the declination, in the line

of natural ſines, and meaſure it in the line of ſines from the beginning, and it ſhall give the ſine of the difference; but if the ſum exceed 90, then when the latitude and declination is alike, add the exceſs to the declination; but if contrary ſubſtract one out of other, and meaſuring the ſum or remainder from the beginning of the ſines, you have the difference which you muſt keep.

Then lay the firſt or left leg to the coſine of the altitude, and the ſecond to the ſecant of the latitude, or elſe lay the firſt to the coſine of the latitude, and the other to the ſecant of the altitude, and note the turnes between, then lay the firſt leg to the ſine of the difference before found, and the other ſhall ſhew the verſed ſine of the Azimuth from noon required, if the verſed ſines be ſet as before is expreſſed, that is to ſay 90 of right ſines, and verſed ſines together, and numbred forwards as the ſines be: but in the uſe of this inſtrument,

ment, the remedy aforeſaid ſupplyeth the defect.

Example.

At 10.19. altitude, 23.32. declination, 51.32. latitude, to finde the Azimuth.

The ſum of the coaltitude and colatitude is 118.09, the exceſs above 90, with right ſine of declination added is 60.30, found by natural ſines, then ſay, As the coſine of latitude, to the ſecant of altitude, ſo is the ſine of the difference 60.30, to the verſed ſine of the Azimuth, but here to the verſed ſine of an ark beyond Radius unknown, then as the verſed ſine of 0, to that ark, ſo is the verſed ſine of 90, to the ver. ſine of 60, the azimuth from noon, whoſe complement to 180, is 125 the Azimuth from Sonth required.

Having been ſo large in theſe, I ſhall in the reſt contract my ſelf as to the repetition, and onely give the Canon for the propoſitions following, the way of working being the ſame in

all other, as in these before rehearsed, and note also what is to be done by the Serpentine-line, is to be done by the three same lines of numbers, sines and Tangents on the edge of the Sector, by altering the term leg, to to the point of the Compasses. The Canons follow.

PROP 4.

Having latitude, declination, and hour given, to finde the Suns altitude at that hour or quarter.

And first for the hour of 6.

As the sine of 90,
To the sine of the latitude 51.30:
So is the sine of the declination 23. 30,
To the sine of the altitude at 6. 18. 13.

Secondly, for all hours in the Equinoctial.

As the Radius or sine of 90, *to the cosine of the latitude* 51.32 : *so is the sine of the Suns distance from* 6 (*in hours and minutes, being turned into degrees and minutes* 30, *for* 8. *or* 4,)

To the fine of the altitude of the Sun at the time required 18. 07,

But for all other times ſay,

As the fine of 90,

To the cotangent of the latitude 38. 28.

So is the fine of the Suns diſtance from 6, 30, 0,

To the tangent of the 4 arke 21 40.

Which fourth arke muſt be taken out of the Suns diſtance from the Pole 66, 21, (in *Cancer*) leaveth a reſidue 44 48, which is called a fift ark. But for the hours before and after 6, you muſt add the fourth arke to the Suns diſtance from the Pole, and the Sum is the fifth ark. Then ſay,

As the coſine of the fourth ark 78, 20,

Is to the fine of the latitude 51, 32:

So is the coſine of the reſidue 45, 12,

To the fine of the Suns altitude at 8, 36, 42, at that declination.

PROP:

PROP. 6.

Having the latitude, declination, and Azimuth, to finde the Suns altitude at that Azimuth.

And first to finde the Suns altitude at any Azimuth in the æquator. Then,

As the sine of 90, to the cosine of the Suns Azimuth from the South 50,0,
So is the corangent of the latitude 38, 28, to the tangent of 27,03. the Suns altitude, at that Azimuth required.

Secondly, to find it at all other times, do thus:

As the sine of the latitude 51, 32,
To the sine of the Suns declination, 23, 32:
So is the cosine of the Suns altitude in the æquator, at the same Azimuth from the vertical, *viz.* 30, to the sine of a 4th. ark 28, 16.

Which fourth ark must be added to the Suns altitude at the æquator in all Azimuths under 90, from the meridian, where the latitude and declination are alike.

But

But in Azimuths more then 90 from the meridian, take the altitude in the æquator out of the fourth ark, and the ſum or remainder ſhall be the altitude required, *viz.* 42, 56. But when the latitude and declination are unlike, as with us in winter time, then take the fourth ark out of the altitude at the æquator, and you ſhall have the altitude belonging to that Azimuth required.

PROP. 7.

Having the hour from noon, and the altitude to find the Suns Azimuth at that time.

As the coſine o fthe al titude,
To the ſine of the hour,
So is the coſine of the Suns declination,
To the ſine of the Azimuth required.

PROP. 8.

Having the Suns Azimuth, Altitude, and declination, to find the hour of the day.

A sthe coſine of the declination,
To the ſine of the Suns Azimuth:

So

So is the cosine of the altitude,
To the sine of the hour.

PROP. 9,

Having the latitude and declination, to find when the Sun shall be due East or West.

As the tangent of the latitude,
To the tangent of the Suns declination,
So is the sine of 90,
To the cosine of the hour from noon.

PROP. 10.

Having the latitude and Suns declination, to find the Amplitude.

As the cosine of the latitude,
To the sine of the declination:
So is the sine of 90,
To the sine of the amplitude from the East or West, toward North or South, according to the time of the day and year.

PROP. 11.

The latitude and declination given, to find the time of the Suns rising before or after 6.

As

As the cotangent of the latitude,
To the ſine of 90:
So is the tangent of the Suns declination, to the ſine of the Suns aſcentional difference between the hour of 6 and the Suns riſing.

PROP. 12.

Having the Suns place, to find his declination, and the contrary.

As the ſine of 90,
To the ſuns diſtance from the next equinoctial point,
So is the ſine of the ſuns greateſt declination,
To the ſine of his preſent declination required.

PROP. 13

The greateſt and preſent declination given, to find the Suns right aſcenſion.

As the tangent of the greateſt declination,
To the ſine of 90:
So the tangent of the preſent declination,
To the right aſcenſion required.

Onely

Onely you must regard to give it a right account by considering the time of the year, and how many 90s. past.

PROP. 14.

To find an altitude by the length, and shadow of any perpendicular object.

Lay the hair on one legg to the length of the shadow found on the line of numbers, and the hair of the other leg to the length of the object that caused the shadow found on the same line of the numbers; then observe the lines between, and which way when the legs are so set, bring the first of them to the tangent of 45, and the other leg shall shew on the line of tangents, so many turns between, and the same way the tangent of the altitude required.

Thus may you apply all manner of quest. to the Serpentine-line & work them by the same Canons, that you use for the Logarithms in all or most Authors.

PROP. 15.

To square, and cube a number, and to findethe square root, or cube root of a number.

The

The ſquaring of a number, is nothing elſe but the multiplying of the number by it ſelf, as to ſquare 12 is to multiply 12 by 12, and then the cubing of 12, is to multiply the ſquare 144 by 12, & that makes 1728, and the way to work it, is thus: Set the firſt leg to 1, and the other to 12, then ſet the firſt to 12, and then the ſecond ſhall reach to 144, then ſet the firſt to 144, and the ſecond ſhall reach to 1728, the cube of 12 required: but note, the number of figures in a cube, that hath but one figure is certainly found by the line, by the rule aforegoing: but if there be more figures then one, ſo many times 3 muſt be added to the cube, and ſo many times two to the ſquare.

To find the ſquare root of a number, do thus: Put a prick under the firſt, the third, the 5th, the 7th, & the number of pricks doth ſhew the number of figures in the root; and note if the figures be even, count the 100 to be the unit, if odde as 3, 5, 7, 9, &c.

the

the 10 at the beginning must be the unit, as for 144, the root consists of two figures, because there is two pricks under the number, and if you lay the index to 144 in the numbers, it cuts on the line of Logarithms 15870, the half of which is 7915 whereunto if you lay the index, it shall shew the 12 the root required; but if you would have the root of 1444, then divide the space between that number, and 100 you shall finde it come to 8,4140 that is four turnes, and 4140 for which four turnes, you must count 80000, the half of which 8,4140, is 4,2070, whereunto if you lay the index, and count from 1444 or 100, at the end you shall have it cut at 38 lack four of a 100.

To extract the cubique root of a number, set the number down, and put a point under the 1, the 4th, the 7th, and 10th, and look how many pricks, so many figures must be in the root, but to finde the unity you must consider, if the prick falls on the last figure,

figure, then the 10 is the unit at the beginning of the line, as it doth in 1728, for the index laid on 1728, in the Logarithms, sheweth 2, 3760, whose third part 0, 7920 counted from 10, falls on 12 the root, but in 17280, then you must conceive five whole turnes, or 1000 to be added, to give the number that is to be divided by three, which number on the outermost circle in this place, is 12, 3750. by conceiving 10000 to be added, whose third part counted from 10, *viz.* two turnes or 4. 125, shall fall in the numbers to be near 26. But if the prick falls of the last but 2, as in 172800 then 100 at the end of the line, must be the unit, and you must count thus: count all the turnes from 172830 to the end of the line, and you shall finde them to amount to 7, 6250, whose third part 2, 5413 counted backward from 100, will fall on 55, 70 the cubique root required.

PROP.

PROP. 16.

To work questions of interest or progression, you must use the help of equal parts, as in the extraction of roots, as in this question, if 100 l. yield 106 in one year, what shall 253 yield in 7 year? Set the first leg to 10 at the beginning, in this case representing a 100, and the other to 106, and you shall finde the legs to open to 253 of the small divisions, on the Logarithms, multiply 253 by 7, it comes to 1771, now if you lay the hair upon 253, and from the place where the index cuts the Logarithms count onwards 1771, it shall stay on 380 l. 8 s. or rather thus: set one leg to the beginning of the Logarithms, and the other to 1771 either forward or backward, and then set the same first leg to the sum 253, and the second shall fall on 380. 8 s. according to estimation; the contrary work is to finde what a sum of money due at a time to come, is worth in ready money: this being premised here, is enough for

for the ingenious to apply it to any queſtion of this nature, by the rules in other Authors. However you may ſhortly expect a more ample treatiſe, in the mean time take this for a taſte and farewell.

The Uſe of the Almanack.

Having the year, to finde the day of the week the firſt of *March* is on in that year, and Dominical letter alſo.

Firſt if it be a Leap-year, then look for it in the row of Leap-year, and in the column of week-days, right over it is the day required, and in the row of dominical letters is the Sunday letters alſo: but note the Dominical letter changeth the firſt of *January*, but the week day the firſt of *March*, ſo alſo doth the Epact.

Example. In the year 1660, right over 60 which ſtands for 1660, there is G for the Dominical or Sunday letter, beginning at *January*, and T for thurſday the day of the week the firſt of *March* is on, and 28 underneath for the epact that year, but in the year

1661,

1661. being the next after 1660 the Leap-year, count onwards toward your right hand, and when you come to the last column, begin again at the right hand, and so count forwards till you come to the next Leap-year, according to this account for 61, T is the dominical letter, and Friday is the first of *March*.

But to finde the Epact, count how many years it is since the last Leap-year, which can be but three, for every 4th is a Leap-year, and adde so many times 11 to the epact in the Leap-year last past, and the sum, if under 30, is the Epact; if above 30, then the remainder 30 or 60, being substracted is the Epact for that year. Example for 1661. 28 the epact for 1660, and 11 being added makes 39 from which take 30, and there remaineth 9, for the Epact for the year 1661 the thing required.

Note that in orderly counting the years, when you come to the Leap-year, you must neglect or slip one, the reason

reaſon is, becauſe every Leap-year hath two dominical letters, and there alſo doth the week day change in the firſt of *March*, ſo that for the day of the month, in finding that the trouble of remembring the Leap-year is avoided.

To find the day of the Month.

Having found the day of the week, the firſt of *March* is on the reſpective year; then look for the month in the column, and row of months: then all the daies right under the month are the ſame day of the week the firſt of *March* was on, then in regard the days go round, that is change orderly every ſeven days, you may find any other ſucceſſive day ſought for.

Example. About the middle of March 1661 *on a Friday, what day of the month is it?*

Firſt the week day for 1661 is Friday, as the letter F on the next collumn beyond 60 ſheweth; then I look for 1 among the months, and all the days right under, *viz.* 1, 8, 15, 22,

29

29. in *March*, and *November* 61, are Friday, therefore my day being Friday, and about the middle of the month, I conclude it is the 15th day required.

Again in *May* 1661. on a Saturday about the end of *May*, what day of the month? *May* is the third month, by the laſt rule I find that the 24 and 31 are Fridays, therefore this muſt needs be the 25 day, for the firſt of *June* is the next Saturday.

FINIS.

ERRATA.

PAge 23. l. 4. adde 1660 p. 24. l. 6. for 5 hours r. 4. l. 9. for 3. 29. r. 4. 39. l. 12 for 5. 52. r. 4, 52. l. 13. for 3. 39. r. 4. 39. l. 17 for 5 hours 52. r. 4. 52. p. 27. l. ult. dele or 11. 03. p 31. l 4. for ſun r. *ſum*. p. 50. l. 8. for B r. A. p. 50 d CHAP. XII. p. 51. l. 16. for 6. 10. r. 6 to 10. p. 71. l. 6. for $\frac{2}{4}$ r. $\frac{1}{4}$. l. penult. for 2 afternoon, r. 1. p. 74 l. ult. for 1. r. 1, 2. p. 83. l. 18. for B C r. B D. p. 69 l. 17. add *meaſure*, p. 129 l. 24. for right of, r. *right ſine of*. p. 114 l. 9 for 18 3. r. 18 13. p. 147 l. 2 for 20, r. 90 p. 163. l. 16. for of, r. *on*.